ORIGINAL ARTICLE
DOI:10.5152/EssentDent.2023.23015

ISTANBUL UNIVERSITY
CERRAHPAŞA

In Vitro Evaluation of the Effect of Soft Tissue Samples Produced Using Different Gingival Masks on Implant Angulations

Beytullah Ak[1], Tayfun Bilgin[2]

[1]Department of Prosthodontics, Istanbul University Institute of Health Sciences, İstanbul, Turkey
[2]Department of Prosthodontics, Istanbul University Faculty of Dentistry, İstanbul, Turkey

Cite this article as: Ak B, Bilgin T. In vitro evaluation of the accuracy of soft tissue samples produced using different gingival masks. *Essent Dent.* 2023;2(3):70-79.

Abstract

Objective: Our study aimed to observe the effects of different gingival masks and production techniques on model accuracy.

Methods: Impressions were taken from an upper jaw model with 6 parallel implants using the open tray technique. Then, 20 models were produced using 3 different gum masks; each group was divided into those produced as single- and double-piece forms. The produced models were scanned using a laboratory scanner. Scanned data were observed for the angular changes of each analog, and the average angular deviation values were calculated for each model. All 6 groups were compared with each other. Kruskal–Wallis test was used in order to evaluate the level of significance.

Results: It was observed that the samples made of a harder type of additional silicone showed more angular deviation compared to the samples made of a softer type of additional silicone and condensation silicone. The production technique, whether single or double piece, did not show any effect on model accuracy.

Conclusion: Based on this study, it was observed that harder types of silicone gingival masks had the advantage of being easy to use and manipulate but showed more angular deviation than other groups included in the study.

Keywords: Gingival mask, implant-supported fixed dental prosthetics, model accuracy, impression, total edentulism

INTRODUCTION

In today's dental practice, the implant-supported prosthetic treatment approach is frequently preferred for the solution of tooth loss due to various reasons or dental deficiencies. In recent years, with the advancement of technology and biocompatible materials, the long-term success of implant-supported prostheses in cases of tooth loss has been supported by multiple studies in the literature.[1,2]

One important factor to consider for the long-term success of implant-supported prostheses is the ability to achieve passive fit restorations. Studies have indicated that the lack of passive fit can lead to various complications.[3,4] In order to achieve this fit between the restoration and the supporting tissues, proper impression techniques must be applied in the clinic, and the precision in creating the master model during restoration fabrication processes becomes crucial.

Since the increase in implant-supported restorations, various materials, such as impression or soft liner materials, have been proposed to mimic soft tissues in the master models created during the conventional laboratory fabrication of tooth or implant-supported restorations.[5-8] However, due to reasons such as the difficulty of application or adherence to similar chemical properties of the impression surface, the use of various physical and chemical gingival masks specifically designed for this purpose has become more common among manufacturers. Mostly applied around the analog in implant impressions, the gingival mask allows the restoration to be fabricated in a manner that is suitable for the soft tissue in contact

Corresponding author: Beytullah Ak
e-mail: beytullahak3@gmail.com

Received: July 24, 2023
Accepted: August 31, 2023
Publication Date: October 19, 2023

with the restoration during the fixed prosthesis fabrication stages, allowing the restoration to be repeatedly removed and reseated on the implant without damaging the emergence profile or causing wear or deformation in the master model.[6] However, it should be noted that alcohol used as a plasticizer in these materials can evaporate due to polymerization, causing dimensional changes. Although it is reported that this expected change will not affect the restoration fit due to the small amount of gingival mask used during model fabrication,[6] as the number of implants and the distance between implants increase in the fabrication of restorations involving a full arch, the amount of gingival mask used in the model fabrication stages will also increase. Therefore, the potential dimensional changes that can be observed should be carefully evaluated, as they can affect the passive fit of the restoration and the long-term success of the prosthesis.

The aim of our study is to evaluate the effects of using different gingival masks with different physical and chemical properties and the preference of 2 different fabrication methods on model accuracy.

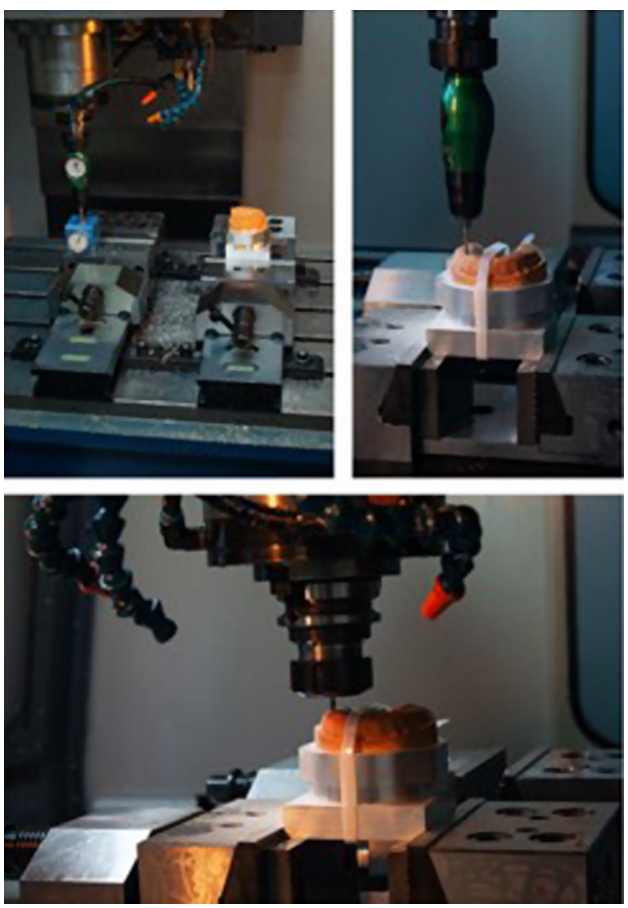

Figure 1. CNC (Computer Numeric Control) device calibration and opening gaps in the model for analogs.

METHODS

In our study, an upper jaw model containing 6 parallel analogs (TS Fixture Lab Analog Regular, Osstem, Seoul, South Korea) was prepared as the main model. To simulate the condition of complete edentulism, a commercially available upper jaw model with removable teeth (Frasaco AG-3, Frasaco, Tettnang, Germany) was used. The teeth were first removed from the model, and the sockets were filled with cotton and wax to simulate the healed alveolar ridge morphology after tooth extraction. Type 4 dental stones (Fujirock EP Optiflow, GC, Alsip, Ill, USA) were used during the duplication stage of the prepared upper jaw model due to its rigidity and faster scanning time compared to other types of dental stones. To standardize the positions and angles for placing the analogs, the original model was digitally transferred using an optical scanner. Then, a guide was digitally created to determine the positions of the analogs, which were designated as 16-14-13-23-24-26 from right to left. To focus on the differences between the gingival masks to be used in the study, the analogs were placed parallel to each other (Figure 1).

Silicone matrix (RVT2 molding silicone, Armasil, Armağan Boya, Istanbul, Turkey) was produced by using the main models for the impression trays to be used in this study.

For impression stages, type A monophase vinyl polysiloxane impression material (Variotime-Heavy Tray, Kulzer, Germany) compatible with the impression mixing device (Renfert Sympress, GC, Alsip, Ill, USA) was used.

To ensure equal amounts of material usage in the soft tissue samples to be produced, the areas where gingival masks would be applied were prepared by milling on the

Figure 2. Production of plaster guides.

Figure 3. Limiting the area for gingival mask application with a plaster guide.

pre-made plaster models (Figure 2) These areas, covering the entire arch and surrounding the implant tissues in 2 separate parts, were emptied, and guides were produced using 2 separate plaster models. The plaster guides were placed on the impressions, and then gingival masks were injected up to the notches specified in the vertical marks on the guide (Figure 3) Three different gingival mask brands commonly used and easily accessible for mimicking soft tissue during laboratory procedures for implant-supported restorations (Gingifast Elastic, Zhermack, Marl, Germany; Gingifast Rigid, Zhermack; Gi-Mask, Coltene, Altstätten, Switzerland) were selected. While a silicone impression gun was used for the Gingifast elastic and rigid groups during the application, the product-provided special mixing container, spatula, and application syringe were used for the Gi-Mask group (Figure 4).

After the polymerization of the soft tissue samples was completed, type 4 hard model plaster (Elite Rock-Thixotropic, Zhermack) was poured, and each model was trimmed, completing the final adjustments before scanning. Scanned data were saved in STL format, and GeoMagic Control software was used for comparison. After defining the main model as a CAD body in the software, the planes on the main model were determined using the body of the scanning parts as references. Then, 6 vectors passing through the center of each analog were determined, and the angular differences were recorded for comparison.

Figure 4. GI-Mask gingival mask, separator, and application syringe.

Ethical Statement

This research did not need an ethics committee approval since it was solely designed with dental materials and did not contain human or animal subjects. Therefore, there was no need for an informed consent.

RESULTS

According to the comparison results between groups A, B, and C, group A exhibits statistically significant higher average deviation values compared to group B. When all groups are examined, the order of angular deviation values from least to greatest is as follows: group B, group A, and group C (Table 1, Figure 5).

No significant difference was found between the groups divided into S and D techniques among the group A samples (Table 2, Figure 6).

Comparing the groups divided into single-piece and double-piece gingival masks among the samples produced with elastic gingiva, no significant difference was found (Table 3, Figure 7).

No significant difference was found between the groups divided into S and D techniques among the group C samples (Table 4, Figure 8).

DISCUSSION

In today's dental practice, the success of implant-supported treatments, which are frequently preferred for full and partial tooth loss, has been supported by numerous studies in the literature.[9-13] However, certain criteria must be met for an implant-supported prosthesis to be considered successful. One of the most important factors among these criteria

Table 1. General Angular Deviation Values of All Groups

		A (Gingifast Rigid)	B (Gingifast Elastic)	C (Gi-Mask, Coltene)	*P*
23	Mean ± SE	0.8048 ± .4187	0.643 ± .4869	0.5966 ± .3381	.258
	Median (minimum-maximum)	0.7332 (0.2116-1.7114)	0.4998 (0.0268-1.85)	0.5519 (0.1379-1.1435)	
24	Mean ± SE	1.0374 ± .4942	0.6714 ± .4399	0.8123 ± .3459	.049
	Median (minimum-maximum)	1.1067 (0.2295-1.888)	0.4998 (0.0958-1.5783)	0.8331 (0.2679-1.7823)	
26	Mean ± SE	1.0317 ± .6651	0.6234 ± .5040	1.0142 ± .4514	.007
	Median (minimum-maximum)	0.858 (0.2042-2.7647)	0.4669 (0.0792-1.8151)	0.9529 (0.4604-1.8643)	
13	Mean ± SE	0.81 ± .3962	0.5154 ± .3758	0.7086 ± .4524	.051
	Median (minimum-maximum)	0.7374 (0.1446-1.3992)	0.4084 (0.1042-1.3959)	0.6822 (0.0757-1.6934)	
14	Mean ± SE	0.974 ± .5372	0.6933 ± .4941	0.7178 ± .4998	.126
	Median (minimum-maximum)	0.777 (0.1787-1.8106)	0.478 (0.159-1.7464)	0.5682 (0.0361-1.6384)	
16	Mean ± SE	0.9556 ± .5145	0.7398 ± .4815	0.9341 ± .5536	.310
	Median (minimum-maximum)	0.9563 (0.2904-1.9288)	0.6174 (0.164-1.8847)	0.791 (0.1268-2.1945)	
Avarage	Mean ± SE	0.9356 ± .3902	0.6477 ± .3286	0.7973 ± .2770	**.011**
	Median (minimum-maximum)	0.8416 (0.3819-1.5335)	0.5477 (0.3852-1.6407)	0.739 (0.3993-1.2953)	

that affect the long-term success of the restoration is passive fit. Although there are studies evaluating the precision of implant-level impression techniques in the literature, there is no consensus on the minimum values required to achieve passive fit.[14] However, while achieving complete passive fit may not be possible, minimizing the mismatch between the final restoration and the supporting tissues is necessary for long-term success.[15] In cases where passive fit is not achieved in implant-supported prostheses, there is a possibility of experiencing mechanical and biological complications in the restoration and peri-implant tissues. Mechanical complications such as loosening, wear, or fracture of implant components, as well as biological complications resulting from disrupted marginal fit due to plaque accumulation, leading to bone loss in the peri-implant tissues, can affect the long-term success of implant-supported prostheses.[15-17]

To manufacture implant-supported restorations that meet the ideal criteria, the intraoral condition needs to be accurately transferred to the laboratory, and working models need to be created. For this purpose, various impression techniques have been developed. The choice of the correct impression technique is the first step in minimizing discrepancies and should meet the requirements of ease of application, minimum working time, and ensuringthe production of accurate models.

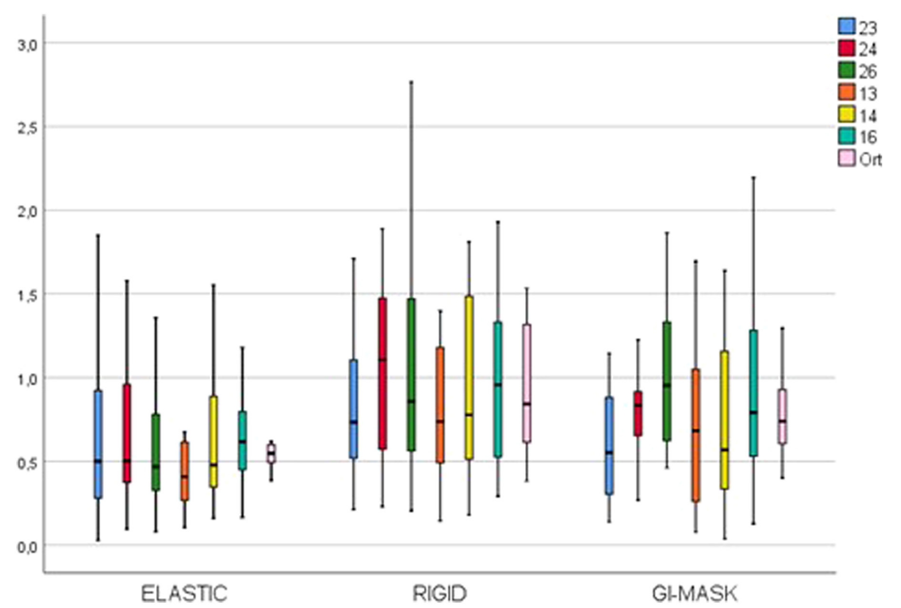

Figure 5. Graph of angular deviation values for all groups.

Table 2. Angular Deviation Values of Rigid Gingival Masks Produced with Different Techniques

Group A		Double	Single	*P*
23	Mean ± SD	0.6242 ± .3660	0.9854 ± .4045	.052
	Median (minimum–maximum)	0.5784 (0.2116-1.376)	0.8871 (0.3447-1.7114)	
24	Mean ± SD	0.993 ± .5535	1.0818 ± .4527	.650
	Median (minimum–maximum)	1.1254 (0.2295-1.888)	1.1067 (0.4189-1.6687)	
26	Mean ± SD	0.7726 ± .5169	1.2908 ± .7194	.082
	Median (minimum–maximum)	0.6812 (0.2042-1.7587)	1.1135 (0.5439-2.7647)	
13	Mean ± SD	0771 ± .4071	0.849 ± .4029	.821
	Median (minimum–maximum)	0.6913 (0.3071-1.3992)	0.9306 (0.1446-1.3185)	
14	Mean ± SD	0.8935 ± .5549	1.0545 ± .5358	.545
	Median (minimum–maximum)	0.6599 (0.1787-1.7382)	1.0495 (0.2849-1.8106)	
16	Mean ± SD	0.8941 ± .5642	1.0172 ± .4817	.496
	Median (minimum–maximum)	0.7434 (0.2904-1.9288)	1.0322 (0.3268-1.7743)	
Avarage	Mean ± SD	0.8247 ± .4088	1.0464 ± .3565	.199
	Median (minimum–maximum)	0.7472 (0.3819-1.4722)	0.9701 (0.5781-1.5335)	

The traditional methods used during the impression phase of implant-supported prostheses are open (direct/pick-up) and closed (indirect/transfer) tray techniques.[18] In many clinical studies related to this subject, it has been reported that impressions taken using the open tray technique are more accurate compared to impressions taken using the closed tray technique.[19-21] Therefore, in our study, the open tray technique was used.

Another essential factor for the long-term success of implant-supported prostheses is having a compatible relationship with the surrounding gingival tissue. This harmony is influenced by factors such as oral hygiene habits, the relationship between the prosthesis boundaries and the free gingiva around the implant, and the roughness of the surfaces in contact with the tissue.[5-8,22-26] Overcontoured restorations contribute to food impaction, gingival infections, and hyperplasia in the oral cavity.[5,6,8,22,25] From this perspective, accurately transferring the relationship between the restoration and the soft tissue in the pontic areas and the emergence profile of the gingiva becomes crucial. To ensure the longevity of the restoration and meet esthetic and phonetic expectations, it is necessary to simulate the better relationship of the restoration with soft tissue in the production models. Models made entirely of rigid plaster hinder the production of restorations that are compatible with the

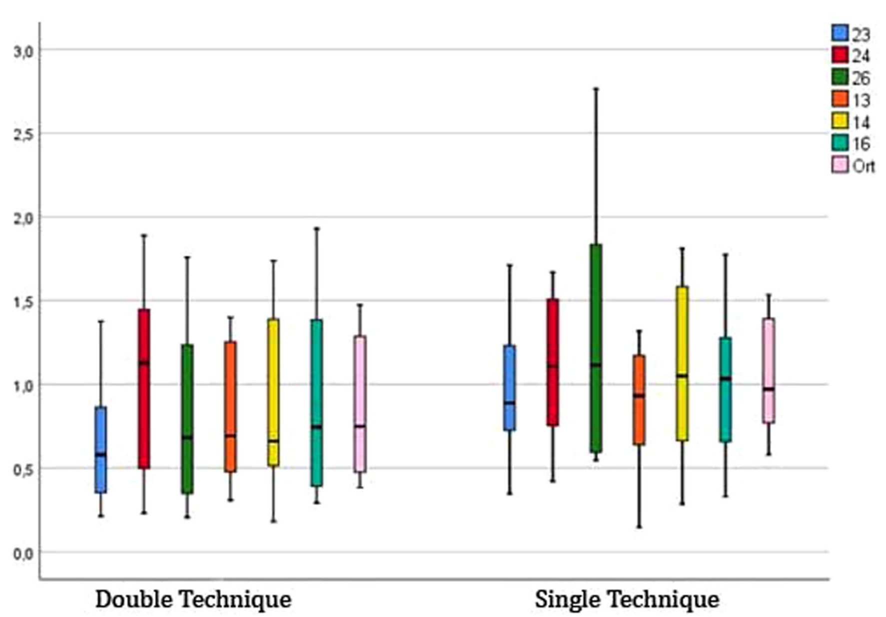

Figure 6. Graph of average deviation values for group A samples produced in single-piece or double-piece form. *S.D.: Standart deviation

Table 3. Angular Deviation Values of Elastic Gingival Masks Produced with Different Techniques

Group B		Double	Single	*P*
23	Mean ± SD	0.7076 ± .5600	0.5784 ± .4215	.705
	Median (minimum–maximum)	0.5917 (0.0268-1.85)	0.4998 (0.1046-1.4708)	
24	Mean ± SD	0.7832 ± .5433	0.5596 ± .2926	.545
	Median (minimum–maximum)	0.4846 (0.0958-1.5783)	0.5159 (0.1252-1.1149)	
26	Mean ± SD	0.6273 ± .5752	0.6196 ± .4531	.597
	Median (minimum–maximum)	0.4501 (0.0792-1.7772)	0.4669 (0.2828-1.8151)	
13	Mean ± SD	0.6311 ± .4980	0.3996 ± .1430	.762
	Median (minimum–maximum)	0.4686 (0.1042-1.3959)	0.3456 (0.2528-0.6653)	
14	Mean ± SD	0.7262 ± .6025	0.6604 ± .3874	.650
	Median (minimum–maximum)	0.4396 (0.159-1.7464)	0.5732 (0.2849-1.5522)	
16	Mean ± SD	0.8065 ± .5907	0.6732 ± .3613	.762
	Median (minimum–maximum)	0.6598 (0.164-1.8847)	0.6174 (0.2553-1.5958)	
Avarage	Mean ± SD	0.7136 ± .4171	0.5818 ± .2105	.545
	Median (minimum–maximum)	0.5495 (0.3852-1.6407)	0.5477 (0.411-1.1515)	

surrounding tissue since the physical properties of the plaster can cause deformations during the restoration production stages and cannot simulate the resilience of soft tissue. Therefore, the use of materials that simulate the free gingiva on the working model becomes important in the production phase of the restoration.

In previous studies, various materials that can be used in different areas of dentistry have been suggested for this purpose. Wilkinson et al[8] proposed the use of a different impression material with similar physical properties to simulate soft tissue during the production of implant-supported prostheses, as the soft tissue masks currently available for simulating soft tissue in implant impressions have not yet been produced. Wilkinson et al applied the additional type of silicone (Extrude, Kerr-Sybron, Brea, Calif, USA) by injecting the polysulfide impression material (Permlastic, Kerr-Sybron, Brea) into the analog environment before pouring the taken impression and completed the model production by making corrections on silicone using a scalpel and pouring dental stone. The author stated that it is necessary for both impression materials used in this method to have different chemical structures for the success of this method, and it can be used in all implant-supported prosthesis production models regardless of the gingival level. They also mentioned that it can transfer the surrounding tissue of the implant to the working model more effectively and contribute to the production of compatible restorationsIn our study, when gingival masks with the same chemical

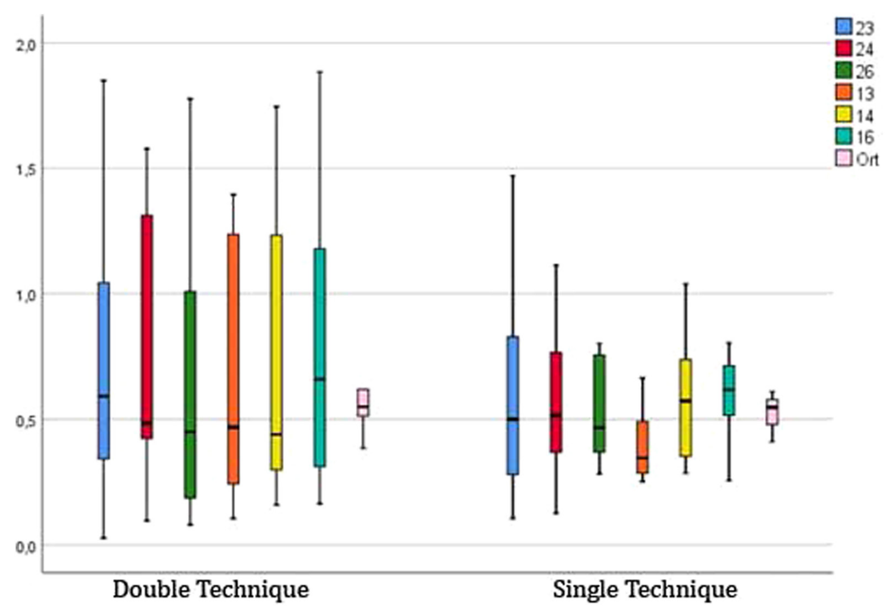

Figure 7. Graph of average deviation values for group B samples produced in single-piece or double-piece form.*S.D.: Standart deviation

Table 4. Angular Deviation Values of Condensation Silicone Gingival Masks Produced with Different Techniques

Group C		Double	Single	*P*
23	Mean ± SD	0.6487 ± .3628	0.5445 ± .3219	.450
	Median (minimum–maximum)	0.597 (0.2267-1.1435)	0.5074 (0.1379-1.1332)	
24	Mean ± SD	0.8219 ± .2085	0.8028 ± .4571	.762
	Median (minimum–maximum)	0.8331 (0.4719-1.2263)	0.8316 (0.2679-1.7823)	
26	Mean ± SD	1.0839 ± .4729	0.9445 ± .4424	597
	Median (minimum–maximum)	1.036 (0.4604-1.8188)	0.814 (0.4771-1.8643)	
13	Mean ± SD	0.8098 ± .4639	0.6075 ± .4405	.290
	Median (minimum–maximum)	0.7622 (0.0757-1.6934)	0.4827 (0.1337-1.4266)	
14	Mean ± SD	0.6615 ± .4970	0.7742 ± .5228	.597
	Median (minimum–maximum)	0.5623 (0.0361-1.4789)	0.6523 (0.1467-1.6384)	
16	Mean ± SD	0.9696 ± .7030	0.8985 ± .3872	.821
	Median (minimum–maximum)	0.7571 (0.1268-2.1945)	0.8741 (0.2653-1.4977)	
Avarage	Mean ± SD	0.8326 ± .2669	0.762 ± .2967	.450
	Median (minimum–maximum)	0.7971 (0.3993-1.2953)	0.7132 (0.4308-1.2737)	

properties were used with the matrix impression material, care was taken to use a separator in accordance with the manufacturer's instructions, so as not to create thickness on the surface. Although it is a commonly preferred and practical method today, plaster guides were used in our study to ensure standardization in the production of soft tissue samples.

Bassiouny et al[5] emphasized the importance of surface characteristics and compatibility with surrounding gingival tissues for achieving the expected long-term success of fixed restorations. They suggested that excessive contouring of restorations can cause complications such as plaque accumulation and gingival hyperplasia, while less contoured restorations produced to avoid excessive contouring can lead to impaired phonetics and poor aesthetics. They stated that materials capable of simulating soft tissue should be used in the laboratory model in order to regulate this situation in a controlled manner under laboratory conditions and produced working models using 2 different types of silicone gum masks (Gi-Mask, Coltene; Soft Tissue Moulage, Kerr Corp.) and polyether-based impression material (Permadyne, 3M-Espe, Neuss, Germany). According to the study results, all 3 materials used in this study have ideal tear and deformation resistance, and they can be used to simulate soft tissue around restorations in the production stages of implant-supported and fixed prostheses. In this study, in addition to the preferred gum masks, a condensation-type silicone gum mask (Gi-Mask, Coltene) was included due to its sufficient color

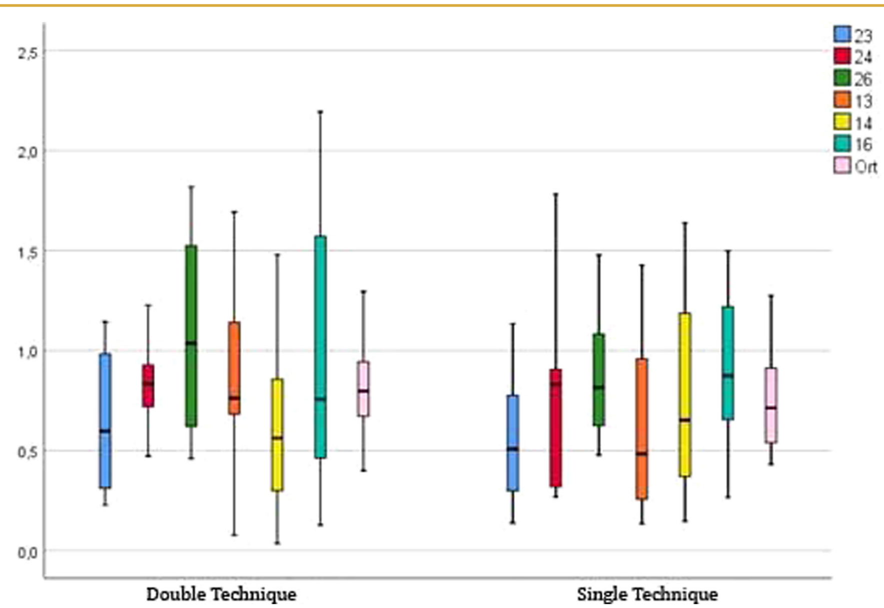

Figure 8. Graph of average deviation values for group C samples produced in single-piece or double-piece form.*S.D.: Standart deviation

and physical properties and its practical use, which is still in production.

In a case report published by Chee et al,[27] 2 implants were placed in the regions of teeth 12 and 22 after the extraction of the anterior 4 teeth, and soft tissue shaping was aimed before permanent restorations through temporary restorations. It was stated that when esthetic criteria are taken into account, the transferability of gingival shaping in this region to the model as it is will increase the long-term success of the restoration. Impressions were taken using temporary restorations to transfer the shaped soft tissue to the working model, and after injecting polyether-based impression material into the analogs before producing the model, the process of pouring plaster was started. In this way, the reshaped soft tissue during the healing process was included in the production stages of the permanent restoration to achieve minimum deformation and ideal esthetics. In a study conducted by Man et al[24] for the same indication, a different method was proposed to produce a soft tissue sample on the master model through a single impression taken at the implant level using silicone keys and closed spoon copings created while temporary restorations were present in the mouth. After removing the plaster around the analogs, screw-retained temporary restorations were placed in the model, and a polyvinyl siloxane-based gum mask was injected through the holes opened in the pre-formed silicone keys in the mouth, thus creating soft tissue around the implant. The requirement for natural teeth to ensure the fit of the key limits the applicability of the method. Although it is one of the transfer methods closest to the real implant emergence profile, it was stated that it may reduce patient comfort, especially in the production stages of anterior implant-supported restorations, due to the need to remove temporary restorations from the mouth. In our study, these transfer techniques mentioned in these studies were not preferred since the soft tissue around each implant was designed in the same way in the master model and temporary restorations were not used.

Nayyar et al[25] conducted a study expressing that the use of soft tissue samples during the production stages of fixed dental prostheses with tooth-supported restorations would enhance the harmony between the restoration and the surrounding soft tissues, leading to more successful restorations. In their study, they proposed a different method from traditional techniques to produce these models. After creating support models using fiber-reinforced rods and acrylic resin for each supporting tooth in the taken impression, a soft liner material was applied around these teeth using an injector. Nayyar et al stated that if the separator provided by the manufacturer was not carefully applied and evenly spread, the 2 materials would stick together, causing deformation in the model. To overcome this complication, they mixed the soft liner material (Coe Soft, GC, Alsip, Ill, USA) used in removable dentures with red typewriter ink. After filling the remaining parts of the impression with plaster, the model production was completed. Before applying restorations with multiple units to the patient's mouth, final checks were performed on this model to improve the fit and shorten the clinical working time. Patil et al[28] suggested a technique to increase the effectiveness of this method. They stated that in their proposed technique, a master model was produced from a single impression, and immediately afterward, the same impression was used to create the soft liner material injected into the segmented master model, allowing the production of soft tissue samples. Similarly, Tan et al conducted a study with the same goal. Before placing the retraction cord, they used the impression taken as a key to inject the soft liner material into the master model, forming the unretracted gingival morphology. They stated that the final check of the restoration on this model would increase harmony with the surrounding gingival tissue, and soft liner materials could be used through separators to mimic the soft tissue for these procedures.

Orenstein et al[7] suggested the use of a polyvinylsiloxane-based transparent bite registration material (Memosil Transparent Bite Registration Material, Kulzer, Hanau, Germany) that could also be used as a gingival mask during laboratory procedures. This material allows the observation of the abutment's fit on the analog without removing the gingival mask, especially when the abutment is milled with attention to the gingival level. They mentioned that using this material would enable the production of soft tissue samples without any changes in the gingival level of the model, thus facilitating the creation of restorations where the soft tissues around the implant are preserved. To limit the area of application of the material, keys made of irreversible hydrocolloid impression material that could easily separate from the polyvinylsiloxane impression material were placed on the surface of the impression before injection. Plaster separator (Super-Sep Dental Stone Separating Agent; Kerr Manufacturing Co., Romulus, Mich, USA) was applied to the impression surfaces to prevent the adhesion between the impression and the material. According to the study results, the gingival mask produced using this method allows the detection of prosthetic errors due to misfit without removing the gingival mask, which facilitates the production of restorations where the health of the peri-implant soft tissues is preserved.[7] In our study, to standardize the production of soft tissue samples, keys made of type IV dental stone (Elite Rock-Thixotropic, Zhermack) were used instead of irreversible hydrocolloid impression material. These keys could be used repeatedly without deformation and maintain dimensional stability.

Elian et al[29] stated that using 2 different impressions obtained with temporary restorations and impression copings at the implant level would increase the accuracy of the method for transferring the emergence profile in the production of implant-supported restorations. In this method, an irreversible hydrocolloid impression was taken with the temporary restoration in place, and then it was poured with condensation-type silicone. The cervical one-third of the restoration was completed on this model because of its flexible structure. However, it was noted that the model's flexibility could cause compatibility issues with the intraoral tissues, and therefore, the restoration was transferred to a plaster model for further production steps. It was also mentioned that the complete silicone model showed greater dimensional changes compared to the plaster model after polymerization, making it difficult to achieve a passive fit between the restoration and the supporting tissues, especially in cases with multiple implants. Therefore, in our study, samples in each gingival mask group were planned to be produced as single and 2 separate pieces, with the remaining parts completed with type IV dental stone (Elite Rock-Thixotropic, Zhermack), to compare the effect of the amount of gingival mask used on dimensional stability.

Beyak et al[6] conducted a study on the transfer of soft tissues around implants to the laboratory environment during the production of implant-supported restorations. They addressed the esthetic problems that arise from cylindrical implants not adequately reflecting the root morphology of natural teeth at the gingival level. They examined the applicability and compatibility of various elastomeric impression materials and soft tissue model production materials available in the market along with different matrix impression materials. One of the common problems encountered with these materials is the dimensional change caused by the evaporation of plasticizing agents or their interaction with the impression material used.[6] Three different polyether, 2 polysulfide, and 1 polyvinylsiloxane impression materials were included as matrix impression materials in the study. Two materials with different chemical properties, which are commonly used for producing gingival masks and are either addition or condensation silicone types, were included for creating soft tissue samples. These materials were applied with and without separators. After the mixing of each matrix impression material, the soft tissue materials were applied following a 15-minute waiting period for complete polymerization. In particular, the samples that included polyvinylsiloxane with either polyether or polysulfide impression materials showed incomplete polymerization on the surface after 15 minutes, and these groups were left untouched for 24 hours for further examination. After the 24-hour waiting period, the materials were manually separated from each other and observed. In the sample pairs of materials with similar chemical compositions included in the study, the samples became a single piece after polymerization. Due to the residual sulfur from the polymerization reactions, it was observed that the polymerization reactions were not completed on the surface where the polyether and polysulfide matrix impression materials were in contact with the polyvinylsiloxane samples. The use of polyvinylsiloxane samples without separators was not ideal due to the adhesion between the 2 materials when it is used with the material showing similar chemical properties.

As a result of the study, the group with condensation silicone materials applied with separators was considered the most ideal due to its mechanical properties. However, due to its complexity compared to other materials, the choice of the most compatible gingival mask material and its application with a separator was recommended.[6] When selecting the groups to be included in our study, the principle of the material being specifically available on the market for this purpose and being sold with a separator was taken into consideration. In our study, polyvinylsiloxane was used as the impression material, and separators were applied to the impression surface before injecting the gingival mask, according to the manufacturer's recommendation.

Evaluation of the Effect of Different Gingival Masks on Model Accuracy

When examining the findings of our study, it was observed that the analogs in group B, which included samples made of rigid type silicone, exhibited statistically significant ($P < .05$) higher angular distortion compared to the analogs in group A, which were made of elastic type silicone (Table 1). The average values of dimensional distortion, from least to greatest, were as follows:

1. Group B (Gingifast Elastic, Zhermack).
2. Group C (Gi-Mask, Coltene).
3. Group A (Gingifast Rigid, Zhermack) (Figure 6).

Evaluation of the Effect of Quantity and Shape of Gingival Masks on Model Accuracy

In the study, each group, exhibiting different chemical or physical properties, was divided into single-piece and double-piece samples, taking into account the first and second regions within the oral cavity. Based on the results:

- No significant difference was observed between the single-piece and double-piece samples prepared from rigid-type silicone in group A ($P > .05$) (Table 2).
- No significant difference was observed between the single-piece and double-piece samples prepared from elastic type silicone in group B ($P > .05$) (Table 3).
- No significant difference was observed between the single-piece and double-piece samples prepared from condensation-type silicone in group C ($P > .05$) (Table 4).

CONCLUSION

1. In gingival masks exhibiting different physical properties but the same chemical structure, the dimensional changes observed on implant analogs are significantly higher in rigid-type gingival masks compared to elastic type samples.
2. Samples made of condensation-type silicone, which exhibits different chemical properties, show average values between the other 2 groups. However, considering the ease of application and working time, it can be stated that condensation-type silicones are clearly disadvantageous.

3. The amount and volume of material used during production do not cause angular changes in analogs. Therefore, having a gingival mask even in areas with long distances between implants during laboratory procedures for full-arch implant-supported restorations will increase the harmony of the restoration with the surrounding soft tissues.
4. It can be stated that after the completion of model production, it is easier to perform adjustments with rotary or cutting instruments on samples made of rigid-type silicone and condensation-type silicone compared to the elastic group. Therefore, when planning gingival contouring or adjustments around the analog on the model, considering this feature will provide convenience.
5. Although not included in our study, comparing the accuracy of models produced through 3D printers, which is becoming increasingly common nowadays, with models produced through conventional methods, more research is needed in this area as the digital method eliminates many disadvantages associated with manual precision.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – B.A.; Design – T.B.; Supervision – B.A.; Resources – B.A.; Materials – B.A.; Data Collection and/or Processing – B.A.; Analysis and/or Interpretation – B.A.; Literature Search – B.A.; Writing Manuscript – B.A.; Critical Review – B.A.; Other – B.A.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. Oral implantology. Glossary of implant terms. *J Oral Implantol*. 2007;Suppl(1):2-14.
2. Pal T. Fundamentals and history of implant dentistry. *J Int Clin Dent Res Organ*. 2015;7(3):6. [CrossRef]
3. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants*. 1986;1(1):11-25.
4. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. *J Prosthet Dent*. 1989;62(5):567-572. [CrossRef]
5. Bassiouny MA, Yearwood LL. Establishing the gingival emergence profile of restorations by using a resilient gingival replica. *J Prosthet Dent*. 1996;76(4):386-389. [CrossRef]
6. Beyak BL, Chee WW. Compatibility of elastomeric impression materials for use as soft tissue casts. *J Prosthet Dent*. 1996;76(5):510-514. [CrossRef]
7. Orenstein IH, Petrazzuolo V, Gorczyca P, Chun JH. Use of transparent polyvinylsiloxane to replicate gingival peri-implant soft tissue. *J Prosthet Dent*. 2003;90(4):410-412. [CrossRef]
8. Wilkinson MR, Woody RD. A soft tissue simulated cast for implant prosthesis. *J Prosthet Dent*. 1992;68(3):553-554. [CrossRef]
9. C, M., *Contemporary Implant Dentistry*. Mosby-Elsevier; 2008.
10. M, E., *Clinical Indication and Treatment Planning in Osseointegration*. 2nd ed. Quintessence; 2008.
11. Patras M, Martin W. Simplified custom impression post for implant-supported restorations. *J Prosthet Dent*. 2016;115(5): 556-559. [CrossRef]
12. Payne AG, Alsabeeha NH, Atieh MA, Esposito M, Ma S, Anas El-Wegoud M. Interventions for replacing missing teeth: attachment systems for implant overdentures in edentulous jaws. *Cochrane Database Syst Rev*. 2018;10(10):CD008001. [CrossRef]
13. S, R., L. M, and F. J. *Contemporary Fixed Prosthodontics*. 3rd ed. Mosby; 2001
14. Ozcelik TB, Ozcan I, Ozan O. Digital evaluation of the dimensional accuracy of four different implant impression techniques. *Niger J Clin Pract*. 2018;21(10):1247-1253. [CrossRef]
15. Kan JY, Rungcharassaeng K, Bohsali K, Goodacre CJ, Lang BR. Clinical methods for evaluating implant framework fit. *J Prosthet Dent*. 1999;81(1):7-13. [CrossRef]
16. Karl M, Rosch S, Graef F, Taylor TD, Heckmann SM. Static implant loading caused by as-cast metal and ceramic-veneered superstructures. *J Prosthet Dent*. 2005;93(4):324-330. [CrossRef]
17. Pujari M, Garg P, Prithviraj DR. Evaluation of accuracy of casts of multiple internal connection implant prosthesis obtained from different impression materials and techniques: an *in vitro* study. *J Oral Implantol*. 2014;40(2):137-145. [CrossRef]
18. Lee H, So JS, Hochstedler JL, Ercoli C. The accuracy of implant impressions: a systematic review. *J Prosthet Dent*. 2008;100(4): 285-291. [CrossRef]
19. Carr AB. Comparison of impression techniques for a two-implant 15-degree divergent model. *Int J Oral Maxillofac Implants*. 1992;7(4):468-475.
20. Hsu CC, Millstein PL, Stein RS. A comparative analysis of the accuracy of implant transfer techniques. *J Prosthet Dent*. 1993;69(6):588-593. [CrossRef]
21. Inturregui JA, Aquilino SA, Ryther JS, Lund PS. Evaluation of three impression techniques for osseointegrated oral implants. *J Prosthet Dent*. 1993;69(5):503-509. [CrossRef]
22. Chaimattayompol N. Simplified method for making a soft tissue mask for a working cast. *J Prosthet Dent*. 2000;83(1):117-118. [CrossRef]
23. Esguerra RJ. Technique for fabricating a custom gingival mask using a maxillary complete-arch implant-supported fixed interim prosthesis with an integrated verification cast. *J Prosthet Dent*. 2016;115(1):5-8. [CrossRef]
24. Man Y, Qu Y, Dam HG, Gong P. An alternative technique for the accurate transfer of periimplant soft tissue contour. *J Prosthet Dent*. 2013;109(2):135-137. [CrossRef]
25. Nayyar A, Moskowitz M, Pollard BL. Improving the emergence profile of dental restorations with accurate reproduction of soft tissue topography. *J Esthet Dent*. 1995;7(1):26-31. [CrossRef]
26. Tan PLB, Ruder GA. Simple(r) soft tissue masque for individual fixed restorations. *J Prosthodont*. 2004;13(3):192-194. [CrossRef]
27. Chee WW, Cho GC, Ha S. Replicating soft tissue contours on working casts for implant restorations. *J Prosthodont*. 1997;6(3):218-220. [CrossRef]
28. Patil PG. Modified soft tissue cast for fixed partial denture: a technique. *J Adv Prosthodont*. 2011;3(1):33-36. [CrossRef]
29. Elian N, Tabourian G, Jalbout ZN, et al. Accurate transfer of peri-implant soft tissue emergence profile from the provisional crown to the final prosthesis using an emergence profile cast. *J Esthet Restor Dent*. 2007;19(6):306-314; discussion 315. [CrossRef]