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Assessment of the flow of impression material into the gingival sulcus depending on the type of impression material used and the impression-taking technique

Ocena zdolności zapływania masy wyciskowej w rowek dziąsłowy w zależności od zastosowanej masy wyciskowej i techniki pobierania wycisku

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HASŁA INDEKSOWE:
masa wyciskowa, rowek dziąsłowy, technika wyciskowa

Summary

Introduction. *Effective preparation of the shoulder margin in abutment teeth for crowns and bridges is the key factor determining the seal and durability of such restorations.*

Aim of the study. *To assess the flow of impression material into the gingival sulcus, taking into account the impression material used and the impression-taking technique.*

Material and methods. *Eight impression materials were tested and six impression techniques were examined. The standard for the study was a model of the mandible and prepared teeth 43 and 46. A simulation was made of gingival sulci 200 µm in width in the region of the abutment teeth. The study material comprised 250 impressions.*

Results. *The greatest material flow in the gingival sulcus was achieved with the two-step two-phase technique without cutting-out a layer of impression material in the cervical area. A two-step two-phase method produced a greater flow of impression material into the gingival sulcus*

Streszczenie

Wprowadzenie. *Granica preparacji stopnia w zębach filarowych pod korony i mosty ma decydujące znaczenie dla szczelności i trwałości tych uzupełnień.*

Cel pracy. *Celem pracy była ocena zdolności zapływania masy wyciskowej w rowek dziąsłowy w zależności od rodzaju użytej masy wyciskowej i zastosowanej techniki wyciskowej.*

Materiał i metody. *Badaniom poddano osiem mas wyciskowych (Aquasil, Honigum, Silagum, Express, Variotime, Impregum, Monophase, Identinum), zbadano sześć technik wyciskowych. Wyciski pobierano na łyżkach standardowych oraz na łyżkach indywidualnych. Wzorcem do badań był model żuchwy z oszlifowanymi pod most zębami 43 i 46. W okolicy zębów filarowych wykonano imitację rowków dziąsłowych o szerokości 200 µm. Wyciski wzorca pobierano z wykorzystaniem specjalnie skonstruowanego urządzenia. Materiał badany obejmował 250 wycisków. Głębokość masy zapływającej w rowek dziąsłowy mierzono za pomocą suwmiarki z funkcją głębokościomie-*

than single-step techniques. Material flow in the gingival sulcus was weaker when impressions were taken with customized trays compared with standard trays.

Conclusions. *1. The deepest flow in the gingival sulcus was achieved with Silagum using a two-step two-phase technique with cut-out interdental spaces. 2. Impression material achieves greater flow in the gingival sulcus when two-step two-phase techniques are used than with one-step one-phase techniques. 3. Impression material applied in standard trays ensured deeper flow in the gingival sulcus than impressions taken in custom-made trays.*

rza. Dla poszczególnych badanych grup obliczono średnie głębokości zapływania masy w rowek dziąsłowy.

Wyniki. *Najgłębiej w kieszonkę zapływały masy w technice dwuczasowej dwuwarstwowej, bez wycinania I warstwy masy w obrębie szyjek zębowych. Głębiej masa wyciskowa zapływała w kieszonki w technikach dwuwarstwowych dwuczasowych w porównaniu do technik jednoczasowych. Podczas pobierania wycisków na łyżkach indywidualnych zaobserwowano mniejszą tendencję masy do zapływania w kieszonkę dziąsłową, niż w przypadku stosowania łyżek standardowych.*

Wnioski. *1. Najgłębiej w kieszonkę dziąsłową zapływa masa Silagum – technika dwuczasowa dwuwarstwowa z wyciętymi przestrzeniami międzyzębowymi. 2. W technikach dwuczasowych dwuwarstwowych masa wyciskowa ma większą zdolność do zapływania w rowek dziąsłowy niż w technikach jednoczasowych jednowarstwowych. 3. Stosując łyżki standardowe masa wyciskowa ma tendencję do głębszego zapływania w rowek dziąsłowy, w porównaniu do wycisków pobieranych na łyżkach indywidualnych.*

Introduction

Effective preparation of the shoulder margin in abutment teeth for crowns and bridges is a key factor determining the seal and durability of such restorations.[1] The shoulders of dental crowns should be prepared at the gingival level. For the dentist this approach ensures good visibility during preparation, an accurate impression of the gingival area (without the need for additional gingival retraction), and insulates the surgical field from crevicular fluids. Additionally, it enables the technician to cast an exact model and to work with precision. During cementation, it guarantees the complete removal of excess cement and, as a consequence, safeguards against any future irritants for the periodontium.[2-4]

Subgingival crowns are recommended only in cases of damage below the gingival line (presence of subgingival fillings, caries), short clinical crowns (to improve retention and stabilization of prosthetic crowns), and significantly discoloured teeth. The grey ring around composite crowns placed in the anterior segment must be concealed subgingivally for aesthetic reasons. When preparing the subgingival zone gingival retraction is essential.[5-7]

The depth of the gingival sulcus in healthy periodontium ranges from 0.5 to 2 mm. On average, it is 1 mm.[8] When periodontitis occurs, the pocket increases in size. An accurate simulation of this zone depends, among other things, on the health of the periodontal tissue, the depth of the subgingival preparation of

Fig. 1. Model with prepared teeth 43 and 46 gingival sulci formed brass.

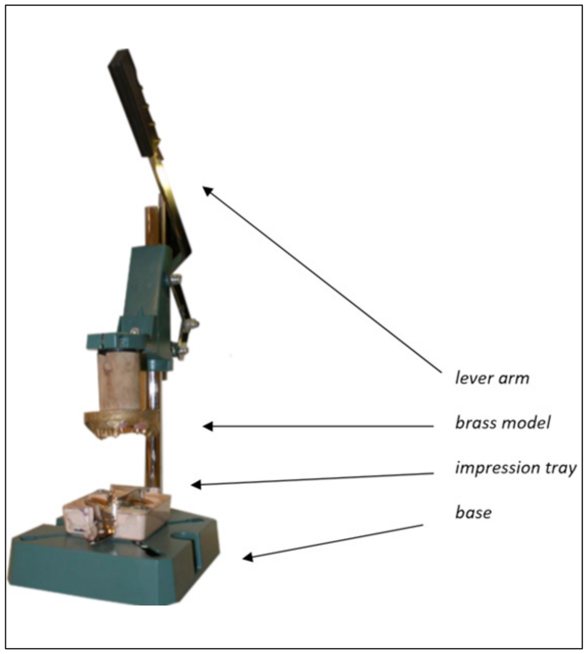

Fig. 2. Impression-taking device.

the tooth, gum bleeding during impression taking, infiltration of the pocket fluid, and the amount of saliva present.[9] It is important to note that prosthetic restorations should be made in patients enjoying good periodontal health.

Of key clinical importance is precise modelling of the prosthetic field in the gingival zone. Material that penetrates deeper into the gingival sulcus provides us with more effective gingival retraction and more precise registration of the preparation margin. A key factor in ensuring precise fitting of prosthetic restorations (crowns, bridges, inlays) is precise modelling of the gingival area, including preparation of the shoulder. The marginal seal and clinical durability of prosthetic restorations depends on meticulous fabrication of the prosthetic restoration and precise bonding with the shoulder prepared in the dental tissue.[10,11]

Objective of study

The objective of this study was to assess the flow of impression material into the gingival sulcus, taking into account the impression material used and the impression-taking technique.

Study material and methods

For the purposes of the study a model of the underlying tissue was formed. Teeth 43 and 46 in a model of a full lower arch (*KaVo, Biberach, Germany*) were prepared for a bridge, in accordance with accepted standards. This model was reproduced in brass and served as a standard for further research. Replicas were made of gingival sulci around the abutment teeth (Fig. 1). To achieve this goal, firstly, some of the material was removed from the gingival area around the abutment teeth to a depth of about 0.5 cm, and then retention elements for the acrylic were fixed in the rest of the brass. The cervical areas of the abutment teeth were covered with 0.2 mm of wax - to imitate the sulci. An acrylic jacket was then made to imitate the soft tissue around the teeth. Following polymerization of the jacket the final acrylic treatment was performed. A small incision was made on the distal aspect of tooth 43, which made it possible to determine the gingival measurement point

Table 1. Study groups

	1	2	3	4	5	6
Aquasil Soft Putty/ Aquasil Ultra LV	10	-	10	10	10	10
Expres XT Penta H/ Express XT Light Body	10	-	10	10	10	-
Honigum-Putty Soft/ Honigum Light	10	-	10	10	10	-
Silagum-Putty Soft/ Silagum Light Fast	10	-	10	10	10	-
Variotime Heavy Tray/ Variotime Light Flow	10	-	10	10	10	-
Impregum Penta	-	10	-	-	-	10
Monophase	-	10	-	-	-	-
Identium Heavy/ Identium Light	10	-	-	-	-	-

Legend:
1 – One-step two-phase technique,
2 – One-step, one-phase technique,
3 – Two-phase correction impression technique with interdental spaces removed and gingival section excised,
4 – Two-step two-phase technique using unprepared abutment teeth in the first impression layer,
5 – Two-step two-phase technique with interdental spaces removed,
6 – One-step technique using individual tray.

(depth of impression material flowing into the gingival sulcus), which had a width of 200 µm.

Eight impression materials were used in the experiment, including five polyvinyl siloxane materials: Aquasil Soft Putty/Aquasil Ultra LV (Densply, Konstanz, Germany), Honigum-Putty Soft/Honigum Light (DMG, Hamburg, Germany), Silagum-Putty Soft/Silagum Light (DMG, Hamburg, Germany), Express XT Penta H/Express XT Light Body (3M ESPE, Seefeld, Germany), Variotime/Variotime Light Flow (Heraeus Kulzer, Hanau, Germany); two polyether materials: Impregum Penta (3M ESPE, Seefeld, Germany) and Monophase (3M ESPE, Seefeld, Germany); as well as well as one form of vinyl siloxane ether: Identium Heavy / Identium Light (Kettenbach GmbH&Co. KG, Eschenburg, Niemcy). The impressions were taken with standard L1 Rim Lock metal impression trays (Falcon, Sialkot, Pakistan) and with light-cured Plaque Photo custom trays (Willmann & Pein GmbH, Barmstedt, Germany). The trays were covered with Vps tray Adhesive (3M ESPE, Seefeld, Germany) for type A silicones, Polyether Adhesive (3M ESPE, Seefeld, Germany) for polyether and Identium Adhesive (Kettenbach GmbH&Co. KG, Eschenburg, Germany) and for vinyl siloxane ether.

Standard impressions were taken using a specially constructed device. Initially, the standard model (of the dental arch) was mounted onto the upper lever of the device (Fig. 2). The impression tray together with the material was placed on a base, in a place ensuring its repeatable and clear orientation. Impressions were taken by lowering the lever arm, which resulted in the model of the standard being

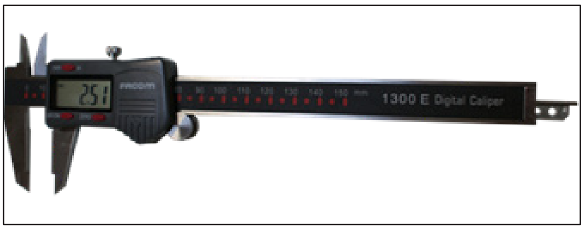

Fig. 3. Calliper with digital readout and depth gauge function.

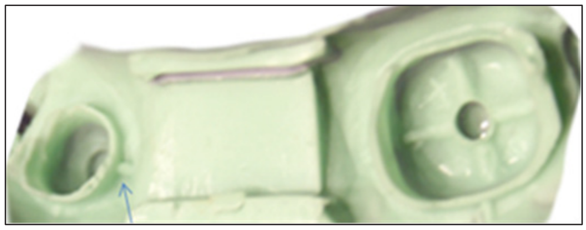

Fig. 4. Impression with the measuring point marked on tooth 43.

placed in the impression tray with material. The point limiting the depth of entry of the model into the material was the edge of the impression tray. The model of the standard remained in the impression tray and material for 12 min. It was decided to extend the recommended time set by impression material manufacturers because the polymerization process took place at a room temperature of approximately 22° C.

The study material comprised 250 impressions – 10 in each study group (Table 1). Each group comprised impressions made with the same impression material and using one of the 6 impression techniques tested and the same type of impression trays. The depth of material penetration into the gingival sulcus was examined and compared in relation to the following impression techniques:

– one-step two-phase technique,
– one-step one-phase technique,
– two-step two-phase technique with interdental spaces and gingival part removed,
– two-step two-phase technique using unprepared abutment teeth in the first impression layer,
– two-step two-phase technique with interdental spaces removed,
– one-step technique using a custom impression tray.

The depth of the material flow into the gingival sulcus during impression taking was measured using a calliper (Facom, Morangis, France) equipped with a digital reading and depth gauge function (Fig. 3). The depth gauge tip was applied to the measuring point on the buccal side of tooth 43 (Fig. 4). The depth of the material flow into the gingival sulcus was measured in mm.

Results

Figure 5 and Table 2 show a comparison of the flow depth of the impression materials in the gingival sulcus with a width of 200 µm, using various impression techniques (mm).

Materials

In the case of the one-step, two-phase technique, all the materials flowed to a similar depth, ranging from 1.524 mm to 1.66 mm.

Material flow in the gingival pocket was weaker when impressions were taken using customized trays and Aquasil and Impregum materials (6) compared with when the same materials were used in combination with standard trays (1, 2; difference for Aquasil – 0.022 mm, for Impregum – 0.224 mm). The weakest flow in the gingival sulcus occurred when Impregum was combined with a one-step technique and a custom tray (6; 0.856 mm).

Material flow was greater with two-step two-phase techniques than with one-step methods (groups 2, 6). Material flow in the pocket was at its deepest when the two-step two-phase technique was used and without removing the first layer of the material from the cervical area of the teeth (ranging from

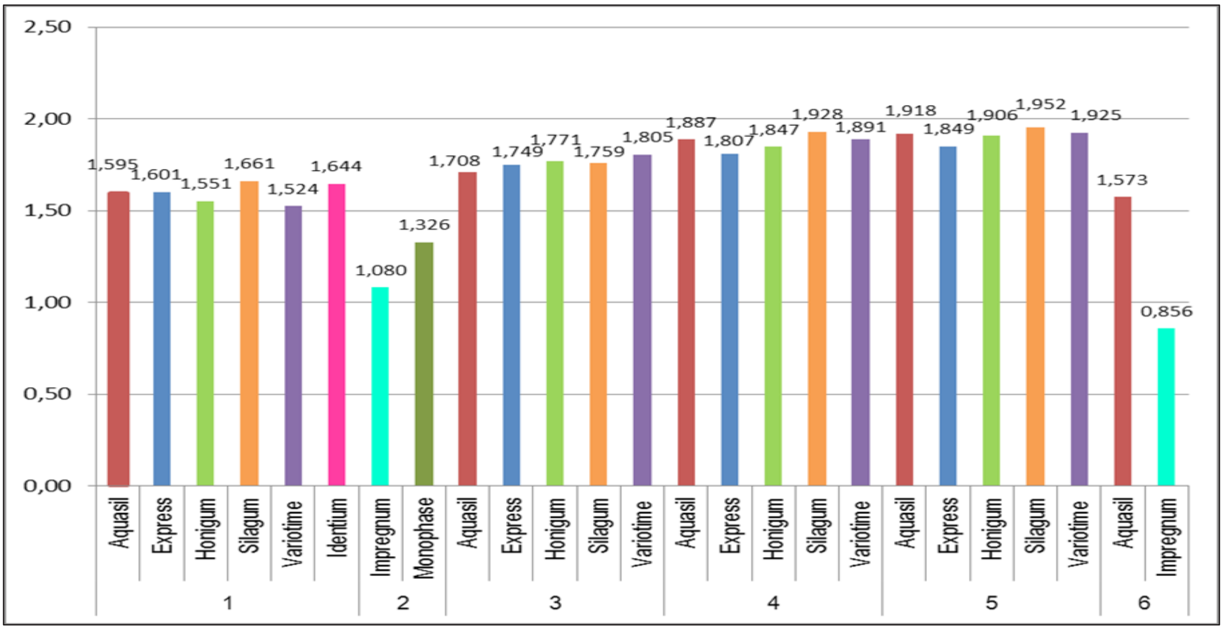

Fig. 5. Depth of flow of impression materials into the gingival sulcus using various impression techniques (mm).
Legend:
1 – one-step two-phase technique.
2 – one-step one-phase technique.
3 – two-step two-phase mix technique with interdental spaces removed and gingival section excised.
4 – two-step two-phase technique using unprepared abutment teeth in the first impression layer.
5 – two-step two-phase technique with interdental spaces removed.
6 – one-step technique using individual tray.

1.708 mm to 1.952 mm). The deepest flow in the gingival pocket was achieved with Silagum in combination with the two-step two-phase technique. The material flow in the gingival sulcus was shallower when the gingival section in the first impression layer was removed (group 3; from 1.708 mm to 1.805 mm).

Impression material flow with a *medium* consistency was weaker in the gingival sulcus (1.08 mm and 1.326 mm) when applying the one-step one-phase technique (2) compared with the one-step two-phase method (*heavy* and *light body*) (1, 3, 4, 5; from 1.524 mm up to 1.952 mm). A comparison of the flow of different impression materials combined with different techniques showed statistically significant differences for most of the analysed materials ($p < 0.001$) with the exception of Impregum ($p < 0.05$).

Discussion

Measurements of impression material penetration in the gingival sulcus revealed that two-step two-phase techniques combined with impression trays produced greater material flow in a 200 µm gingival sulcus than did the one-step two-phase technique, irrespective of the material type. Material flow in the sulcus was considerably weaker with the one-step, one-phase technique. These differences turned out to be statistically significant.

The use of a custom-made tray impeded the ability of impression materials to flow into the gingival sulcus when compared with the singe-step technique utilizing a standard tray. The first layer of a one-step two-phase heavy body impression pushes the light body into the sulcus, while insufficient pressure acts on the medium

T a b l e 2. Comparison of average flow depths for different impression materials depending on the technique used

Impression material	Technique	Calculated parameters					
		min	max	x	Me	SD	v (%)
Aquasil	1	1.45	1.74	1.595	1.615	0.090	5.7
	3	1.58	1.84	1.708	1.690	0.090	5.3
	4	1.74	2.08	1.887	1.870	0.113	6.0
	5	1.72	2.10	1.918	1.930	0.102	5.3
	6	1.44	1.78	1.573	1.545	0.100	6.4
Comparison		F = 26.104; p<0.001					
Express	1	1.49	1.70	1.601	1.615	0.062	3.9
	3	1.62	1.86	1.749	1.755	0.084	4.8
	4	1.72	1.89	1.807	1.810	0.059	3.3
	5	1.78	1.97	1.849	1.835	0.061	3.3
Comparison		F = 25.870; p<0.001					
Honigum	1	1.47	1.63	1.551	1.560	0.057	3.7
	3	1.68	1.86	1.771	1.790	0.064	3.6
	4	1.68	2.07	1.847	1.835	0.123	6.7
	5	1.80	1.98	1.906	1.915	0.053	2.8
Comparison		F = 38.023; p<0.001					
Silagum	1	1.55	1.75	1.661	1.645	0.061	3.7
	3	1.67	1.87	1.759	1.750	0.068	3.9
	4	1.74	2.08	1.928	1.980	0.123	6.4
	5	1.76	2.10	1.952	1.995	0.125	6.4
Comparison		F = 19.697; p<0.001					
Variotime	1	1.40	1.65	1.524	1.535	0.085	5.6
	3	1.74	1.89	1.805	1.815	0.054	3.0
	4	1.77	2.04	1.891	1.885	0.086	4.6
	5	1.83	2.10	1.925	1.920	0.076	3.9
Comparison		F = 56.710; p<0.001					
Impregum	2	0.90	1.22	1.080	1.055	0.13	10.5
	6	0.44	1.19	0.856	0.900	0.233	27.3
Comparison		z = 2.728; p<0.05					

materiak in the customized tray. An even more favourable effect is achieved with a heavy body material in a two-step two-phase impression, in which the first layer after polymerization acts as a press and pushes the light body into the gingival sulcus. Excision of the gingival section in the first layer of the material resulted in a slightly weaker flow of material into the gingival sulcus compared with the other two-step two-phase methods tested. An impression taken with a basic impression material prepared in this way results in less of the *light* material being pushed into the gingival sulcus.

According to *Finger* et al., the two-step two-phase method ensures better simulation of the narrow gingival sulci than the single-step two-phase technique does. However, researchers found no differences between the impression techniques in a simulation of a 200 µm gingival sulcus. *Luthardt* et al. [9] compared the single-mix technique using Impregum with one-step two-phase and two-step two-phase methods combined with PVS Dimension Garant. They showed that the one-step two-phase method produced the most accurate simulation of the gingival section while the single-mix technique achieved worse results in this respect.

Takkahashi et al.[12] studied the flow capabilities of Flexitime polyvinyl siloxane in gingival sulci. They used a material containing surfactants, as well as an equivalent medium without surface tension reducing agents. They compared the flow of the material into sulci with widths of 50 µm, 100 µm and 200 µm within a temperature range of 23-37°C. Although they found statistically significant relationships, they concluded that from a clinical point of view these are of little importance, and the factor that determines effective simulation is the correct opening of the gingival sulcus with a width of 200 µmS. Similar conclusions were reached by *Baharav* et al.[13] in their study of 3 A-silicones (Examix, Elite, Express) and Permadyne. They used six metal standard models shaped like a prepared abutment tooth with a *chamfer* shoulder and grooves of varying width simulating a gingival sulcus (100 µm-400 µm). They did not show any significant variation between the different materials. Nevertheless, a relationship was clearly visible between the width of the sulcus and the accuracy of the simulated gingival part of the cast models. Simulation models with a 100 µm sulcus were characterized by significant distortion. Researchers report that the gingival sulcus should be open to a width of at least 150 µm – in such conditions the model in the gingival section is the least deformed in relation to the standard. The only differences between the materials used in the study were observed in the case of Express, the models of which exhibited greater distortion than was the case with other materials.

Schaefera et al.[14] made impressions of a single metal tooth using Identium, Panasil (VPS) and Impregum. The plaster models of an individual tooth were scanned, and then the resulting image was applied to the scan of the standard. As it turned out, the best material for simulating the gingival section was A-type silicone, followed by polyvinylsiloxane ether. The worst material in this respect was polyether. Scientists point to the excellent flow properties of liquid consistency VPS in the zone during subgingival preparation. *Aimjirakul* et al.[15] demonstrated opposite results. They reported that polyether materials exhibit better penetration in 100 µm and 200 µm pockets than polyvinyl siloxane materials.

In light of the above, the best impression technique for prosthetic restorations involving subgingival preparation of abutment teeth would be a two-step two-phase method using unprepared abutment teeth in the first impression layer or a two-step, two-phase method with interdental spaces removed. The first layer of the material should not be removed from the gingival section.

Conclusions

1. The greatest flow in the gingival sulcus was achieved with Silagum and the two-step two--phase technique
2. The flow of impression material in the gingival sulcus was greater with two-step two--phase techniques than with one-step one--phase methods.
3. Two-phase impressions in standard trays provide more accurate gingival impressions than one-step impressions taken with customized trays.

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