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METHODS OF ASSESSMENT OF DIMENSIONAL STABILITY OF ELASTOMERIC IMPRESSION MATERIALS AFTER DISINFECTION: A LITERATURE REVIEW

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Precise and dimensionally stable impression materials are crucial for a good impression. Still, the precision of the impression and the accuracy of the reproduction depend on several factors, of which the most important one is the method of disinfection and the duration of the same. The purpose of this review article was to look at different recommended procedures for the disinfection of elastomeric dental impressions and the most commonly used methods and equipment for evaluating their dimensional stability after disinfection. To prepare this paper, we performed an electronic search of databases MEDLINE (Pub Med) and Google Scholar for articles published in the period from 2011 to 2022. Thirty-nine papers were selected for being the most current, relevant and focused on the disinfection of elastomeric materials for impressions as well as on methods and equipment applied to the evaluation of dimensional stability of elastomeric impressions after their disinfection. Our analysis showed that the most commonly used disinfectant materials were glutaraldehyde as well as sodium hypochlorite. Disinfection usually lasted for 10−15 minutes. Regarding the methods used to assess dimensional changes, the microscope was used in 26 papers out of a total of 39 papers. The review of the literature confirmed the non-standardization of the methodologies applied in the research and their great variety.

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Introduction

Impression is a routine procedure in all branches of dentistry, especially in fixed and mobile prosthetics (1). It is essential to transfer the condition of the mouth to the model as reliably and accurately as possible (2). Precise and dimensionally stable impression materials are essential for a good impression. Still, the precision of the impression and the accuracy of the reproduction also depend on the way the material is handled, the storage conditions of the impression until the casting of the model, the time spent until the casting of the model, disinfection and its duration (3).

After taking the impression, the dentist must assess whether the impression is sufficiently precise and whether it reliably shows all the structures of the oral cavity. The impression must be taken from a high-precision material because it must faithfully depict all structures, precisely and in detail. Silicone impression materials are widely used due to their excellent physical properties, favourable handling properties and good patient acceptance. Dimensional stability is a characteristic of the impression that indicates the change of the impression after bonding the material to casting with plaster (4). The stability of dental materials refers to the possibility of registration without the influence of time, which gives the operator a chance to obtain an adequate impression (5). This characteristic is an essential requirement in dental and laboratory practice for obtaining accurate replicas and making prosthetic restorations (6).

Literature Review

Dental impressions, contaminated with the patient’s blood and saliva, are a potential infection transmission route. Unfortunately, disinfection of dental impressions was not a routine procedure for many years, but it began to be used on a large scale already at the end of the 20th century. Subsequently, to control the spread of diseases, the American Dental Association (ADA) and the World Dental Federation (FDI) recommended disinfection of dental impressions immediately after removal from the mouth, either by immersion or spraying, using disinfectant solutions (7, 8). The best-known solutions for impression disinfection are sodium hypochlorite, glutaraldehyde, iodine preparations, phenols and chlorhexidine digluconate. In addition, new disinfection methods have been introduced, such as microwave chambers, autoclaving chambers, ultraviolet (UV) light, and ozone. Dimensional stability and precision of two silicone impression materials after chemical disinfection by immersion in disinfectant were investigated. Pronounced changes in the dimensions of all samples were determined as a function of time as well as in the function of the application of the disinfectant. Measurements were taken sequentially using a Canon G9 camera with the Remote Capture software options so that time series photographs of the same print were obtained (9).

The effect of the disinfection method and storage of the tested samples for 6 months after pre-disinfection of one group and sterilization in an autoclave of the other group were investigated and the authors concluded that there were no clinically significant changes in the dimensions of the samples during the storage period using stereomicroscope measurements (10).

The effects of different disinfection methods (UVC, gaseous ozone, commercial solution and spray) on dimensional change in elastomeric materials with different viscosities were compared by Vezgoviec et al. (11). Their results revealed that additional silicones had greater dimensional stability. The study also revealed that similar to standard liquid disinfectants, both UVC and ozone did not affect the physical properties of most silicones. Examination of the changes was performed with Magnuson digital caliper.

Nassar et al. (12) investigated the dimensional stability of 5 consistencies (VPES) stored for up to 2 weeks, with and without the use of a standard disinfection procedure using a microscope at 30x magnification.

According to Guiraldo et al. (13), polysulfide (non-disinfected), polysulfide and polydimethylsiloxane (after disinfection with 0.2% chloramine-T) showed lower mean values of dimensional stability. They came to this conclusion by investigating the stability of four elastomeric materials after disinfection with 0.2% chloramine-T. The entire procedure was performed following the ISO 4823 standard and using an optical microscope.

Soganci et al. (14) compared the dimensional changes of polyether and vinyl polyether siloxane impression materials immersed in two different disinfectants sodium hypochlorite (5.25%) and glutaraldehyde (2%), over three time periods with a 10-micron 3D scanner and 3D software used to assess dimensional changes by superimposition.

Samra et al. (5) analyzed the effect of different disinfection systems on the dimensional stability of commonly used irreversible hydrocolloid and additive silicone impression materials from developing countries compared to materials from developed countries. The disinfectants used were glutaraldehyde, sodium hypochlorite and an ultraviolet chamber, and were examined using a travelling microscope.

Aim

The purpose of this review and study was to review the various recommended disinfection procedures for elastomeric dental impressions and the most commonly used methods and equipment to assess their dimensional stability after disinfection.

Material and Methods

To prepare this paper, we performed an electronic search of MEDLINE (PubMed) and Google Scholar databases and retrieved articles published in the period from 2011 to 2022 using the following keywords: disinfection impression, disinfection method, dimensional stability of impression, type of measurement. From the consulted 45 articles, 39 were selected, the most current, relevant and focused on the disinfection of elastomeric impression materials and methods, and equipment used to evaluate the dimensional stability of elastomeric impressions after their disinfection. *In vitro* studies were of particular interest.

The criteria used to confirm whether a study met the conditions for analysis included in vitro studies focusing on elastomeric materials frequently used in dentistry, the study authors must have followed the protocols of the International Organization for Standards (ISO) 4823 or American Dental Association (ANSI/ADA) Specification No. 19, the materials must have undergone disinfection with the control group consisting of non-disinfected materials, the effect of disinfection on dimensional changes should be explored, and the applied methods evaluated.

Information Analysis

This review included 39 studies related to applied methods for the evaluation of dimensional changes of elastomeric impression materials after their disinfection. Among several methods used for impression disinfection, the chemical immersion method was most commonly used over other methods including microwave irradiation for 3 minutes, steam autoclave for 15 and 30 minutes, UV light for 3, 20 and 40 minutes, disinfection with ozone and EOV (electrolyzed oxidizing water) for 5, 10 and 20 minutes.

Our analysis showed that the most commonly used disinfectants were glutaraldehyde 0.5%, 2%, 2.25%, 2.5% as well as sodium hypochlorite 0.5%, 1%, 2%, 3%, 4%, 5% and 5.25%. Disinfection lasted from 30 seconds to 5, 10, 15, 20, 30 minutes and 1, 2, 3, 12, 16 and 24 hours. Disinfection usually took 10 to 15 minutes. Regarding the methods used to assess dimensional changes, the microscope was used in 26 papers out of a total of 39 papers. Other authors used other methods.

Table 1. Summary of selected studies indicating the methods for the examination of the effect of disinfection on dimensional stability of different elastomeric impression materials

Autor-Year	Impression material	Disinfection material	Time	Type of measurements	Property Investigated
Carvalhal et al. 2011	PDS, PVS, PS, PE	0.5% NaOCL, 2% glutaraldehyde	10, 20, 30, 60 min	Microscope	Dimensional stability
Surendra et al. 2011	Polyvynilsiloxane	Autoclave 121 °C	15 min	Microscope	Dimensional stability
Ahila et al. 2012	PVS	2.25% glutaraldehyde	10, 30 min 1 h	Microscope	Dimensional stability
		5% povidone iodine, 4% NaOCL			
Hiraguchi et al. 2013	A-Silicone	2% glutaraldehyde	30 min 24 h	Laser scan micrometer	Dimensional stability
		0.55% ortho-phthalaldehyde			
Nandini et al. 2013	A-Silicone	2% glutaraldehyde	30 min	Video vision measuring microscope	
Ahila et al. 2014	A-Silicone	2.45%glutaraldehyde, 4% NaOCL			
	C-Silicone	5% povidone iodine	10 min	Travelling microscope	Dimensional stability
Duseja et al. 2014	PE, A-Silicone	Dual phenol	10 min 1 h		Dimensional stability
		2% glutaraldehyde	10 min 1 h	Microscope	
		0.5% sodium hypochlorite	10 min 1 h		
Thota et al. 2014	A-Silicone, C-Silicone, PE	Autoclave	24 h	Stereomicroscope	Dimensional stability
Millar et al. 2014	Silicone(Affinis, Aquasil, Speedex)	Autoclave 134 °C	30 min	Non-contact scanner	Dimensional stability
		2% Perform-ID solution	10 min		
Sinobad et al. 2014	A-Silicone	0.5% glutaraldehyde	10 min	Canon G9 camera	Dimensional stability
	C-Silicone	benzalkonium-chloride-Sterigum			
		5.25% NaOCl			

Pal et al. 2014	PE, A-Silicone	1% NaOCL, 4% NaOCL 2% glutaraldehyde	10 min	Microscope	Dimensional stability
Goodbole et al. 2014	PVS	UV	10 min	Travelling microscope	Dimensional stability
Kamble et al. 2015	PVS, CS, PE	Autoclave, Microwave irradiation 1% NaOCl	10−15 min	Microscope	Dimensional stability
Khinnavar et al. 2015	PVS, PE, A-Silicone	2% glutaraldehyde, 0.525% sodium hypochlorite	16 h	Leica WILD stereomicroscope	Dimensional stability
Hiragushi et al. 2015	A-Silicone	2% glutaraldehyde 0.55% ortho-phthalaldehyde	30 min 24 h	Three-dimensional coordinate Measuring system	Dimensional stability
Demajo et al. 2016	A-Silicone(PVS)	Glutaraldehyde MD520 alcohol	3 h	Scanning microscope	Dimensional stability
Sinobad T. 2016	A-Silicone, C-silicone PE	5.25% NaOCL, glutaraldehyde Benzalkonium chloride Ethanol, isopropyl alcohol	5, 30, 60 min 24 h	Microscope Photometry	Dimensional stability
Nassar et al. 2017	VPES	2.5% buffered glutaraldehyde	30 min	Microscope	Dimensional stability
Guiraldo et al. 2018	PS, PE, PVS Polydimethylsiloxane	2% NaOCl 2% chlorhexidinedigluconate 0.2% peracetic acid	15 min	Microscope	Dimensional stability
Soganci et al. 2018	PE, VPS	5.25% NaOCl, 2% glutaraldehyde	10 min	3D scanner + 3D software	Dimensional stability
Samra et al. 2018	A-Silicone	2% glutaraldehyde, 5.25% NaOCl UV 254 nm frequency	10 min 3 min	Microscope	Dimensional stability
Guiraldo et al. 2018	PDS, PVS, PS, PE	0.2% chloramine-T	15 min	Scanning Tunneling Microscope	Dimensional stability
Azevado et al. 2019	A-Silicone	3% hydrogen peroxide MD 520	10 min 5 min	Visualised with a magnifier glass (Wild/Leica M420), photographed and	Dimensional stability

		1% NaOCl, 5.25% NaOCl	10 min	analysed	
Mahalakshmi et al. 2019	PVS	2% glutaraldehyde,		Microscope	Dimensional stability
		1% NaOCl electrolysedoxidising water EOW	10 min		
Ghasemi et al. 2019	A-Silicone	0.5% NaOCl, Epimax, Deconex	10 min	Digital caliper with 0.01 mm accuracy	Dimensional stability
Nimonkar et al. 2019	PVS	2% glutaraldehyde, 1% NaOCl	20 min	Microscope	Dimensional stability
		UV light	20 min		
Ozdemir et al. 2019	A-Silicone, C-Silicone	1%sodium hypochlorite	10 min	Digital radiography	Dimensional accuracy
	PE	Aldehyde-free disinfectant sol.	3 min		
		Zeta 7 spray			
Khatri et al. 2020	PVS, PE, VPES	2.45% glutaraldehyde	15 min 12 h	Stereomicroscope	Dimensional stability
		3% sodium hypochlorite		Digital Vernier caliper	Surface Detail Reproduction
Asopa et al. 2020	PVS	2% glutaraldehyde	30 min	Travelling stage microscope	Dimensional stability
		heat sterilization	15 min	(NIKON profile projector)	
Yousief et al. 2020	A-Silicone	2% glutaraldehyde	30 min	Travelling microscope	Dimensional stability
Vrbova et al. 2020	Variotime Medium Flow	Aseptoprint Liquid	2 min	Light microscope	Dimensional stability
	Xantopren L Blue	Zeta 7 solution	10 min	Scanning electron microscope	
	Impregum Soft	Silosept	10 min	Micro-computed tomography	
		Dentaclean Form	15 min		
Mohd et al. 2021	PVS, VSE	Silosept	10 min	Image analyzer at 20x magnification	Dimensional change
		Microwave Irradiation	3 min		
Sana et al. 2021	A-Silicone	0.2% chlorhexidine	5–10 min	Stereomicroscope	Dimensional accuracy
	C-Silicone	5.25% NaOCL		Digital Vernier caliper	
	Polyether	2% povidone iodine			
		Ozone water			
		Running tap water			

Kuei-Ling Hsu. 2021	PVS	Birex SE			
		Opti-Cide 3	5 min	Computed tomography (CBCT)	Dimensional stability
		COEfect Minute Spray			
		CaviCide spray			
Abdelhameed et al. 2021	PVS	0.5% sodium hypochlorite	10 min	Three-dimensional analysis	Dimensional stability
				computed tomography	
Alam et al. 2021	Panasil	1% Surfosept	30 sec	Profile projector	Dimensional stability
		2% Deconex			
Wezgowiec et al. 2022	A-Silicone	UVC	40 min, 254 nm	Magnuson digital caliper	Dimensional change
	C-Silicone	Ozone	10 min		
		Zeta 7 solution	10 min		
		Zeta 7 spay	10 min		
Almuraikhi et al. 2022	VPS, PE	2% glutaraldehyde	30 min		
		5.25% NaOCL	20 min	Stereomicroscope 20x	Dimensional stability
Ud Din et al. 2022	3 PVS (experimental) 5 PVS (commercial)	1% NaOCl	30 min 24 h	Travelling microscope	Dimensional change

*PE- Polyether, PVS- Polyvinyl siloxane, PVES- Polyvinyl ether silicone, VSE- Vinyl siloxanether, VPS- Vinyl polysiloxane, PDS- Polydimethylsiloxane

Discussion

Numerous methods are described in the literature for testing the dimensional stability of elastomeric impression materials depending on various factors. The most famous measurement technique is the one set by the International Organization for Standards (ISO 4823), i.e. American Dental Association (ANSI/ADA Specification No. 19). These standards set the most recognized performance specifications for elastomeric impression materials. The first measurements to assess the dimensional stability of the impression material were performed using a microscope and a micrometer screw. During testing, elastomeric materials were used and an impression was taken from a model that is the same or similar to that described in the reference standards, as well as by taking an impression from different master models that simulate prepared teeth. Measurements were made on elastomeric impressions or plaster models obtained from the impressions. A micrometer screw is a measuring instrument with an accuracy of up to 0.01 mm, while digital indicator instruments have an accuracy of 0.005, 0.002 and 0.001 mm. The micrometer screw is an integral part of many measuring instruments, for example, microscopes and telescopes.

A microscope is a more precise device for 2D measurements. There are many types of measuring microscopes, from the simplest to digital microscopes connected with measuring software. A profile projector is a measuring instrument that projects an enlarged image and compares it with an enlarged drawing on transparent paper. A coordinate measuring device is a measuring instrument used for spatial measurement in all three coordinate axes (k, i, z).

Radiographic methods (CT and CBCT) are rarely used in research to analyze prints and patterns.

Desktop digital scanners, or laboratory scanners with associated software packages allow us to perform quality analysis and comparison of impressions and cast models.

The effect of chemical disinfection on impression materials depends on the method and duration of disinfection, the type and concentration of the disinfectant and the type of impression material. In general, disinfection affects not only dimensional stability but also affects the humidity of impression materials, as well as the surface quality of plaster models.

Regarding the methods used to investigate the effect of disinfection on the dimensional stability of elastomeric materials, we concluded that the most frequently used is microscope (5, 6, 13, 15–23); then stereomicroscope (1,24–27); travelling microscope (8, 28–31); scanning microscope (32,33). Other methods include: microscope photometry (34); video vision measuring microscope (35); laser scanning micrometer (36); a noncontact scanner (37); Canon G9 camera (9); three-dimensional coordinate measuring system (38); 3D scanner+3D software (14); visualized with a magnifier glass (Wild/Leica M420), photographed and saved for later analyses with the Image (7); digital caliper with 0,01 mm accuracy (11, 39); digital radiography (40); image analyzer (41); computed tomography (42); three-dimensional analysis computed tomography (43); and profile projector (44).

There is no exact provision in the literature regarding which measuring device should be used in assessing the dimensional stability of elastomeric impression materials. Because of the lack of standardization, it is difficult to compare such studies. Microscopes and calipers are most often used as measuring instruments. Conventional print evaluation methods are mainly two-dimensional methods in which linear accuracy is evaluated by measuring the distance between arbitrarily selected points with various measuring devices in order to prove the material's expansion or contraction.

More modern measurement techniques are available today, such as various measurement software that use digital photographs of specimens or laser scanners to measure digitized impressions and the model. Even so, the most common measurements are still those using a microscope. The method and the use of print evaluation system are limited. They depend on the capabilities of the therapist or researcher, the equipment of the office or laboratory, or the availability of different assessment methods. Limiting factor is the price. In research, the choice of systems and methods for the evaluation of prints depends on the needs of the research, on their goals.

The effect of chemical disinfection on impression materials depends on the method and duration of disinfection, the type and concentration of the disinfectant and the type of impression material. In general, disinfection affects not only dimensional stability, but also affects the humidity of impression materials, as well as the surface quality of plaster models.

According to ADA specifications, elastomeric impressions should not produce more than 1.5% dimensional change (6).

Dimensional stability is the ability of a material to maintain its three-dimensional size and shape over time, under appropriate humidity and temperature conditions. Disinfectants can produce a chemical or physical interaction with impression materials, which can effect on their dimensional stability (7).

Dimensional changes can occur in plaster models as a result of the inherent characteristics of the impression material, such as wetting and viscosity. Other possible causes may be the thickness of the material between the oral tissue and the impression tray, hydrophilicity of the material, loss of by-products, polymerization shrinkage and thermal shrinkage due to temperature (13).

Examining dimensional changes on elastomeric materials, under the influence of the immersion period in two different disinfectant solutions (sodium hypochlorite 0,5% and 2% glutaraldehyde) resulted with conclusion that this combination can be used in the dental office as a disinfection method for period of 20 minutes, without interfering the dimensional stability of the impression materials (15).

In a survey conducted to investigate the dimensional stability of elastomeric materials by method of cold sterilization and immersion, the obtained results showed that PVS with thick consistency showed the highest dimensional stability, while polyether showed the lowest dimensional stability (24).

Dimensional changes of plaster casts after immersing the impression taken with a hydrophilic additive silicone with medium viscosity in disinfectant solutions for 30 min and 24 h were investigated. It was determined that the dimensional changes in the models caused by the immersion of the impressions were less than 15 mm. A three-dimensional coordinate system was used for the evaluation (36).

Conclusion

The review of the literature confirmed the non-standardization of the methodologies applied in the research and their great variety.

The most commonly used methods for disinfection are immersing or spraying the impression with disinfectant. The most commonly used disinfectants are solutions of 2% glutaraldehyde and 0.5% and 1% sodium hypochlorite. The immersion duration for elastomeric impressions in disinfectant is from 10 to 30 minutes.

Regarding the methods used to evaluate dimensional changes, the most commonly used microscopes are light microscope, traveling microscope, scanning electron microscopy, scanning microscope, tool microscope, scanning tunneling microscope and stereomicroscope.

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METODE PROCENE DIMENZIONALNE STABILNOSTI ELASTOMERNIH MATERIJALA ZA UZIMANJE OTISAKA NAKON DEZINFEKCIJE: PREGLED LITERATURE

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Precizni i dimenzionalno stabilni materijali za uzimanje otisaka ključni su za uzimanje dobrog otiska, ali preciznost otiska i tačnost reprodukcije zavise i od još nekoliko faktora; jedan od najvažnijih je način dezinfekcije i njeno trajanje. Svrha ovog preglednog rada bila je da se sagledaju različite preporučene procedure za dezinfekciju elastomernih dentalnih otisaka i najčešće korišćene metode, kao i oprema za ocenu njihove dimenzionalne stabilnosti nakon dezinfekcije. Za potrebe ovog istraživanja izvršili smo elektronsku pretragu *MEDLINE (*PubMed) i baze podataka (*Google Scholar*) i pregledali smo članke objavljene u periodu od 2011. do 2022. godine. Odabrano je 39 najaktuelnijih i relevantnih studija fokusiranih na dezinfekciju elastomernih materijala za uzimanje otisaka, te na metode i opremu primenjene pri proceni stabilnosti dimenzija elastomernih otisaka nakon njihove dezinfekcije. Naša analiza je pokazala da su najčešće korišćeni dezinfekcioni materijali gluteraldehid i natrijum-hipohlorit. Dezinfekcija je obično trajala od deset do petnaest minuta. Kada je reč o metodama korišćenim za procenu dimenzionalnih promena, zapaženo je da je 26 autora od njih 39 najčešće upotrebljavalo mikroskop. Pregledom literature potvrđena je nestandardizacija metodologija primenjenih u istraživanju i njihova velika raznovrsnost.

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Ključne reči: *elastomerni otisci, dezinfekcija, stabilnost dimenzija, ispitivanja*

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