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THE DIMENSIONAL STABILITY OF ELASTOMERIC DENTAL IMPRESSION MATERIALS

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Abstract: High accuracy dental impression is usually a first step during fabrication of indirect restorations that have to be seated in or on prepared teeth. The dimensional stability of the impression material could have an influence on the accuracy of the final restoration. Elastomeric materials (addition- cured silicones and condensation- cured silicones) are most frequently used as the impression material in fixed prosthodontics. The composition and the type of the chemical reaction determine the urgency to cast or digitize the impression. The aim of this study was to asses the dimensional stability of addition and condensation - cured silicones in time.

Stainless steel model of two cylinders with the spherical top was fabricated. First, individual tray of acrylic resin was made according to the standard procedure. Addition and condensation cured silicon impressions were taken using monophase technique in acrylic tray. Impressions were cast in type IV dental stone after different periods of time, and dental stone replica models were made. Master model and dental stone replica models were scanned using Carl Zeiss Coordinate measuring machine Contura G2 with associated volumetric probing tolerance of 1µm. Processing was done using Calypso software.

Addition and condensation cured silicon impressions were cast after different periods of time. Master model and dental stone replica models were scanned and the differences between the models were measured. The dimensional differences between the master model and the replica models occurred due to the dimensional instability of the impression material. The differences were significantly greater when condensation cured silicon impression material was used comparing to the addition cured silicon impression material.

Both condensation and addition silicon showed satisfactory dimensional stability if cast according to the manufacturer's instructions. If so, the linear dimensional changes did not exceed 1%.

Keyword: elastomers, dental impression materials, fixed partial denture.

1. INTRODUCTION

Dental impression presents a negative imprint of orofacial structures. It is usually a first step during fabrication of indirect restorations that have to be seated in or on prepared teeth. The dimensional stability of the impression material could have an influence on the accuracy of the final restoration. Precise working cast can only be obtained on the basis of an accurate impression of teeth and surrounding tissues. Knowing the physical and biological properties as well as the advantages and disadvantages of different impression materials, is a prerequisite for adequate practical application of dental materials and contributes to the success of prosthetic therapy [1]. There are four groups of impression materials that are in use for final impression in fixed prosthodontics: polysulfides, polyethers, condensation and addition silicones. Each group of material has its advantages and disadvantages [2]. Elastomers are a group of elastic impression materials. They consist of polymers that bind together in a network of chains that give material a rubber consistency. They are widely used in fixed prosthetics because of their good properties.

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For the clinical use, the most important difference between addition and condensation silicones is in their relative dimensional stability. Condensation silicones show dimensional changes after setting of the material, which may be caused by their continued slow setting, or by loss of alcohol, as a byproduct of the setting reaction [3]. The second effect produces a measurable weight loss which is followed by a contraction of the impression material. Addition silicones have insignificant number of byproducts released, which provides a dimensionally stable impression [3]. Addition and condensation silicones have similar mechanical properties that depend on their consistency, but differ in required casting time of previously taken impression [4,5]. Condensation silicone should be cast as soon as possible, while for addition silicone dimensional stability of the impression is not time dependent and casting can be done several times without the loss of materials properties [4,5].

In the present study, dimensional stability of condensation and addition silicones was evaluated, depending on the time elapsed between the impression taking and casting in gypsum using coordinate measuring machine.

2. MATERIALS AND METHOD

To assess the dimensional stability of addition and condensation, silicone master model was made. The model represented two steel abutments with a defined distance between them, that corresponded to the distance of bridge abutments inside the patients mouth (Fig 1). Before the research was commenced, master model was measured by coordinate measuring machine (CMM) Carl Zeiss Contura G 2 and results were recorded. Measurements were conducted using mechanical probe with maximum permissible error of 1 µm [6].

Acrylic resin was mixed according to the manufacturer's instructions and an individual tray was made (Fig 2).

Special attention was given to the base of the tray. Positioners were made to ensure position of the tray on top of the model and to allow reproducibility during the course of experiment. The tray was enlarged and had a 2mm space for the impression material, equally distributed on all sides of the abutment. Impression taking was delayed for the first 24 hours after manufacturing of the tray, to avoid possible influence of acrylic contraction on the results [7].

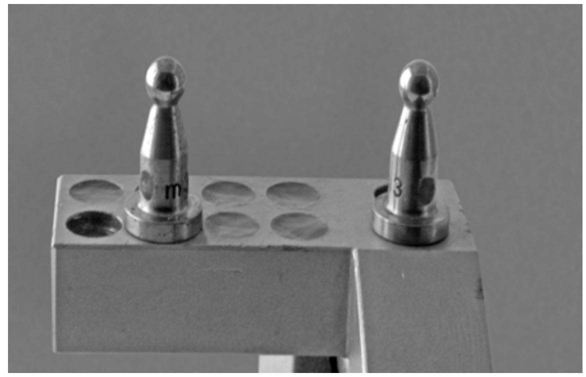

Figure 1. master model

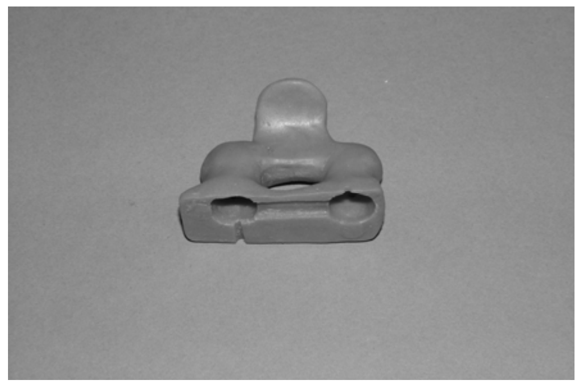

Figure 2. custom tray

Two impression materials were used. Addition silicone *Elite HD+, Zhermack, Italy, light body* and condensation silicone *Oranwash, Zhermack, Italy, light body*. During the research materials were stored in the same room, with stable temperature of 21-23 ^{0}C. To improve stability and adhesion of the material to the tray, universal tray adhesive was used (*Universal tray adhesive, Zhermack, Italy*). The acrylic tray was wiped with alcohol prior to the impression taking and thoroughly dried. Adhesive was applied in a thin layer using a brush and left to dry for 2 minutes, following the manufacturer's instructions. Dosage of condensation silicone was done using the numerated paper dosimeter. Since the diameter of the nozzle of the pastes between the two silicones differed, the amount of the impression material needed to make one imprint was weighed and that quantity was recorded using the numerated paper dosimeter. This generated savings in material and the time spent for impression taking. Impressions were cast at different time intervals since taking of the impression (30 min, 1h, 2h, 4h, 6h, 8h, 10h, 12h, 24h, 36h, 48h, 96h). Replica models were made using tip IV dental stone (*Heraeus Moldastone tipe 4, Heraeus, Germany)*. Gypsum was mixed accor ding to the instructions (100:22) and left to set for one hour before removing the impression tray. Replica models were first stored for 120 hours in the study room, to avoid possible influence of gypsum expansion on accuracy of measurement [8]. Each replica model was measured six times by the same investigator using a CMM and the mean value was recorded as the closest value to the real distance between the replica abutments (Fig 3,4).

3. RESULTS

The results of the measurements for the addition silicone are shown in *Figure 5*. The difference in size already appeared when the first replica model was measured. It was cast 30 min after the impression was taken and the distance between replica abutments was 80 μm larger than on the master model.

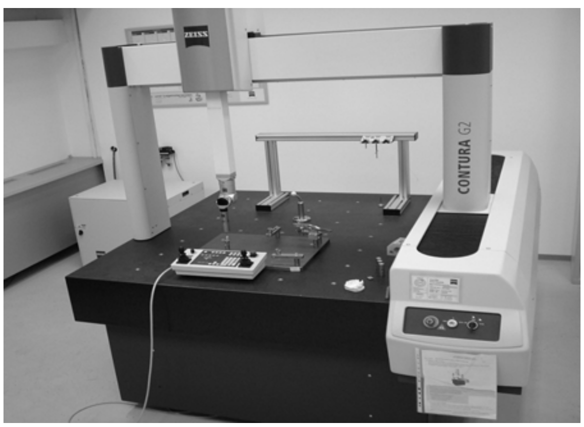

Figure 3. Carl Zeiss CMM (Contura G2)

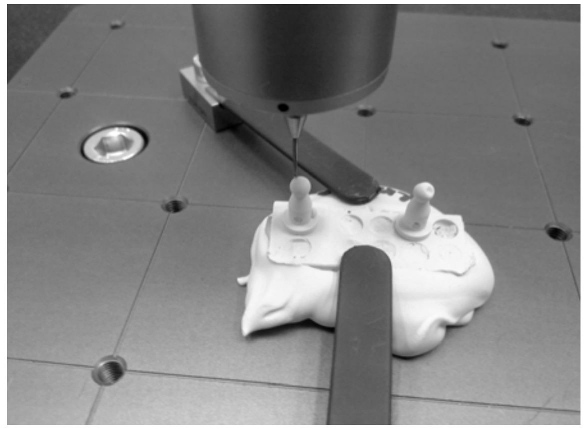

Figure 4. Gypsum replica model

The dimensional variations of all models that were cast during the time interval of 96 hours varied between 70 μm to 99 μm. The greatest difference was observed when the model was cast 96 hours after the impression was made and resulted in 99 μm.

The results of the measurements of the dimensional stability of condensation silicone are shown in *Figure 6*. Variations between gypsum abutments and the master model varied from 2,5 μm to 152,8 μm. The distance between the abutments of the replica model, that was cast after 1 hour after the impression was taken, were 2,5 μm larger than the master model. After 2 hours the distance increased to 14,5 μm and continued to grow as the time between impression making and casting increased. The biggest difference between the replica and master model abutments was measured after the period of 96 hours.

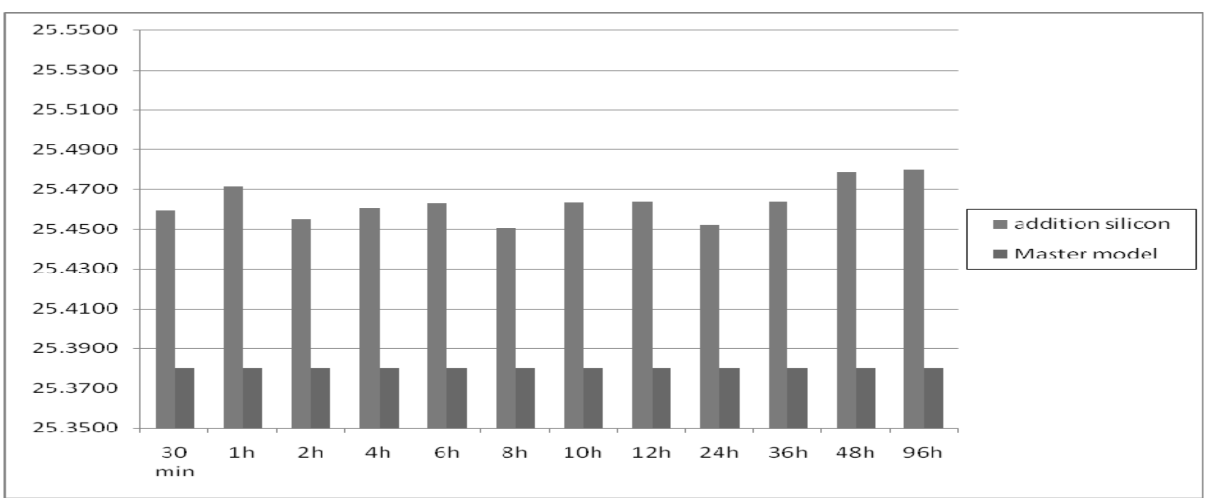

Figure 5. Measured distance between replica abutments using addition silicone

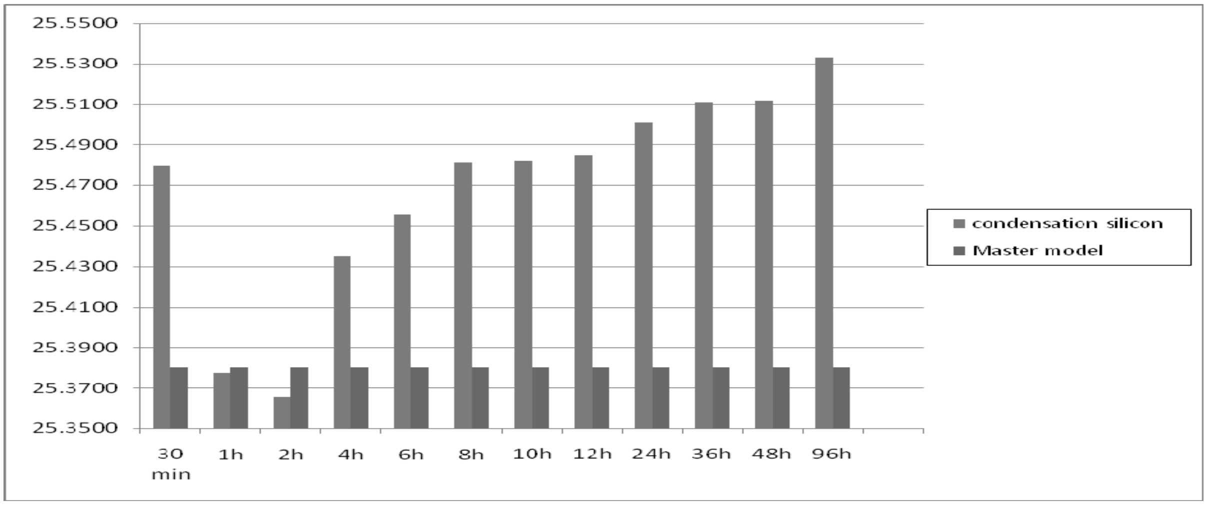

Figure 6. Measured distance between replica abutments using condensation silicone

4. DISSCUSION

Dimensional stability of the impression materials used in prosthetics presents an important factor for the accuracy of dental devices. Dental impression is the first phase of the complicated sequel of dental device manufacture. Each phase contributes to the overall error of the future work and can lead to poor quality and diminished accuracy. An error made in the early stages of production cannot be corrected in further process, but becomes the source of the new errors. That is why the knowledge of impression materials properties is imperative for dental practice, so that a therapist can choose appropriate mass that corresponds to the present situation. Evaluation of dimensional stability has been improved using contemporary scanners [9,10]. Coordinate measuring machine that was used in this study (*Carl Zeiss, Contura G2*) is a complex metrology instrument that is used for measuring lengths and angles of selected objects. The measurement can be made by contact or contactless, automatically or manually. In the case of contact measurements, as it was with the presented study, the contact with the object of measurement is achieved by spherical probe which touches the measured object, thus registering a point cloud that can be further reconstructed to a virtual model [11]. The machine has associated volumetric probing tolerance of 1µm [6]. Coordinate measuring machine Contura G2 that was used in the present study has proven to be a reliable and precise scanner. The combined use of CMM and Calipso software is a convenient method for obtaining virtual models and measuring dimensional differences between master and replica model during the testing of the impression materials dimensional stability.

Since 1755 when impression technique with hot wax was first described, the properties and use of impression materials have significantly improved [12]. Elastomeric impression materials have been widely used across the globe for the last 50 years and are considered to be a gold standard among dental impression materials used in fixed prosthodontics. Their ability to reproduce fine details [13,14], simple and quick preparation, pleasant smell and tactile comfort for the patient together with gypsum compatibility, has positioned them as one of the most suitable materials for impression making in dental industry [15,16].

Dimensional stability of the material is a significant factor for accuracy of dental restoration [10]. Results of the measurement between replica abutments using addition silicone varied from 70µm to 99µm, which is plausible according to the demands of contemporary practice [17]. We concluded that the dimensional stability of addition silicone did not significantly change, not even after 96 hours since the impression was made (linear dimensional changes did not exceed 1%). These results agree with the previous studies of other researchers [10, 16,18]. By contrast, condensation silicone was less stable. The highest accuracy was achieved when the impression was cast after 1 hour. After that contraction progressed and after 96 hours measured the distance was 152,8 µm greater than on the master model. Surprisingly, although dimensional stability decreased over a period of time, the model cast after 96 hours was still acceptably accurate. Condensation silicone contraction was also under 1 %, which differed from the results of previous researchers, who measured contraction of up to 2, 97 % [18]. This can be partially explained by the use of a universal adhesive which may have improved dimensional stability of the impression material, and stable environmental conditions (temperature and moisture) of the storage space [19,20]. However, the results of this study indicate that a precise working cast can be obtained with condensation silicone if the pouring of gypsum is set at appropriate time. Study conducted by Faria et al. stated that the condensation silicones are less accurate than addition silicones, but the casting time between investigated impression materials differed. Condensation silicones were cast immediately, while addition silicones were cast after 1 hour [16]. Immediate casting may have a negative impact on viscoelastic recovery of the impression material and on the accuracy of the working cast. Our research showed that appropriate time for casting impressions when using condensation silicones should be 1 hour. The distance between the replica abutments was approximately 25mm. The question remains, how would an increase in distance and larger number of the abutments (as is the case when making long-span bridges) affect the measurement. The above- mentioned, as well as the different techniques of impression making will be the subject of our future research.

The application of computers and computer-guided systems in dentistry provides us with a new perspective and wider possibilities for intraoral tissue registration, but the use of impression materials will remain a reliable method for years to come.

5. ACKNOWLEDGEMENT

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ДИМЕНЗИОНАЛНА СТАБИЛНОСТ ЕЛАСТОМЕРНИХ МАТЕРИЈАЛА ЗА УЗИМАЊЕ ЗУБНИХ ОТИСАКА

Сажетак: Веома прецизно узимање отиска обично је први корак у изради индиректних рестаурација које треба да буду смјештене у или на припремљене зубе. Димензиона стабилност отисног материјала може утицати на прецизност израђене зубне надокнаде. Еластомерни материјали (адициони полимеризирајући и кондензациони полимеризирајући силикони) најчешће су коришћени материјали за узимање отисака у фиксној протетици. Састав и врста хемијске реакције одређују колико је хитно да се излије односно дигитализује отисак. Циљ овог истраживања је био да се процијени димензиона стабилност адиционих и кондензационих силикона у времену.

Израђен је челични модел од два цилиндра са кугластим врхом. Прво је направљена акрилатна индивидуална кашика, уз поштовање стандардне процедуре. Уз помоћ акрилатне кашике, отисци су узимани монофазном техником, кондензационим и адиционим силиконом. Отисци су изливани у гипсу типа IV након различитих временских интервала, и израђивани су радни модели од гипса. „Мастер модел“ и гипсане репродукције скенирани су помоћу скенера Carl Zeiss Coordinate measuring machine Contura G2 са максималном дозвољеном грешком од 1µm. Обрада је вршена уз помоћ софтвера Calypso.

Отисци узимани адиционим и кондензационим силиконима изливани су у различитим временским интервалима. „Мастер модел“ и његове гипсане репродукције су скенирани и мјерене су разлике између модела. Димензионе промјене између мастер модела и репродукција настале су усљед димензионе нестабилности отисног материјала. Разлика је била значајно већа код отисака узетих кондензационим силиконом у поређењу са адиционим силиконом.

Оба отисна материјала, и кондензациони и адициони силикон, показали су задовољавајућу димензиону стабилност кад су при изливању поштоване препоруке произвођача. У том случају линеарне димензионе промјене нису биле веће од 1%.

Кључне ријечи: еластомери, материјали за узимање зубних отисака, фиксна парцијална протеза.