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Effects of Moisture on Polyether Impression Materials

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by
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Finally, special thanks are extended to all those persons involved in the realization of this investigation.

DEDICATION

In loving memory of my grandparents,
Fernando and Sonia Stepensky and
Abraham Tiktin.
To my grandmother, Sara Tiktin.

To my wife Ilana,
for her love, devotion, and patience.

To my mother and father,
Adela and Moises
for offering the greatest support, encouragement and love throughout my first twenty-four years of life.

To my brothers, Saul and Jose.

VITAE

Fabian Stepensky was born on January 22, 1954, in Mexico, D.F. Mexico, to Moises Stepensky and Adela Tiktin. He is the second of three children, Saul and Jose.

He received his elementary and secondary education in the "Nuevo Colegio Israelita" in Mexico City. He graduated from this school in 1969.

In 1969, he entered Preparatoria #4 in Mexico City, where he finished high school.

In September 1971, after receiving his degree in high school, he spent one year in Israel studying Hebrew and Agriculture.

In September 1972, he entered the freshman class of "Universidad Tecnologica de Mexico". He graduated in August 1976, with the degree of Doctor of Dental Surgery. His efforts were recognized by election to "Best Dental Student in Mexico in the Year 1976-77". (Premio Nacional Academico '76-77)

In August 1976, he entered the Fixed Prosthodontic graduate program at Loyola University of Chicago and began the pursuit of a Master of Science degree in Oral Biology and Certificate of Specialty in Fixed Prosthodontics under the direction of Dr. William F. Malone, Chairman.

TABLE OF CONTENTS

INTRODUCTION

Elastomeric impression materials were introduced in the 1950's. The initial product of this group was polysulfide rubber, followed by the silicones. Polyethers were introduced just recently to the dental profession. The accuracy and dimensional stability of the polyether type of material will be the subject of this study.

The use of elastomeric impression material must comply to a number of standard requirements, begining with an acceptable working and setting time. The materials should be non-toxic, stable after withdrawl from the patient's mouth, and accurate when poured to produce a die which will be capable of reproducing the details of the dentition and allied structures. The impression material should also be strong in thin sections, and elastic enough to be withdrawn without suffering a permanent distortion from undercuts that are very common in prosthodontics.

At this time there are four different types of elastomeric impression materials available for the dental professions: 1. polysulfides; 2. two different types of silicones-addition and condensation polymers; 3. polyether. From these four materials, only polyether was developed specifically for the dental profession.[6] The use and selection of an impression material for dental practice is a difficult decision for the dentist to make. An impression should be stable enough to produce accurate

casts after several days. If the impression is initially accurate, but exhibits belated dimensional instability, its use in dentistry will be limited.

Compared with hydrocolloids, the elastomeric materials are more stable (Philips, 1959), more viscous and therefore less likely to distort when poured (Hampson, 1956). Since 1969, many authors like Chong and Docking (1969), Hannah and Pearson (1969), Rohan (1970), Docking, Schwindling (1970), and others studied a polyether called Impregum. Some of the investigators found polyethers in many aspects to be better than silicones and polysulfides when compared in a time-deformation basis. Others have found polyethers to possess a superior dimensional stability to the remainder of the materials used in dentistry for impressions. For example, Docking (1970), reported Impregum has the most reliable recovery after deformation with less dimensional changes after removal from the patient's mouth. Schwindling stated the greatest shrinkage of Impregum, although minimal, occurred within the first two hours.

The water absorption of this material is one of its greatest drawbacks. Combe and Grant (1973), noted the polyethers were liable to inaccuracies due to water absorption, Hembree et al., (1974), stated, "Moisture has an affect on the dimensional accuracy of this material". He also proved Impregum can be poured three times before appreciable dimensional inaccuracy occurred. Braden in

1972, found Impregum was stable if kept in air, however, if the material was immersed in water, a significant dimensional change was recorded. Finally, Bell in 1976 said, "The dimensional stability of polyether can be affected by their storage conditions".

It is the purpose of this study to measure, under simulated clinical conditions, the effect of moisture on polyethers. Specifically, the accuracy and dimensional stability of polyether impression materials was evaluated under various degrees of humidity at different time intervals.

It is virtually impossible to design a test which will cover every clinical aspect. Nevertheless, the test selected must be capable of providing results which have some practical application. This study clarified: doubts about storage conditions of polyether impressions, the best way to handle the impression, and the way to avoid conditions that can affect accuracy and dimensional stability of the material.

LITERATURE REVIEW

General Aspects

Polyether impression materials were introduced in Germany in 1970.[1] Since then a great deal of research has been reported. This impression material has been tested in a variety of methods, and under different physical conditions. The results have been stated by many authors in various journals. When polyether impression material was introduced in 1970, it was a two paste system: a base and a catalyst. Eventually there was also a body modifier which could be used to decrease the viscosity of the mix and to reduce the rigidity of the set polymer.[1] The working time of this polyether was reported to be two minutes with a setting time of three to five minutes.[2] The coefficient of thermal expansion was found to be greater than that of the polysulfide rubber impression material.[2] In order to reduce inaccuracies during manipulation, temperature variations[2] were to be minimized. Because there was alkyl benzene sulfonate in the catalyst paste, irritation of the patient's soft tissue was possible. Therefore care was exercised in the handling of the material.[2] The tray adhesive was a rubber dissolved in ketones and chloroform, as a result they were very volatile. The vapors produced problems if they had a prolonged exposure to the patient or dentist, and precautions were instituted.[2] The Council of Dental Materials and Devices recommended:

a) Mixture of the base and catalyst to a uniform color before use intraorally.

b) Avoid skin contact with the unmixed catalyst, as this may cause sensitization.

c) In case of skin contact wash with soap and water.

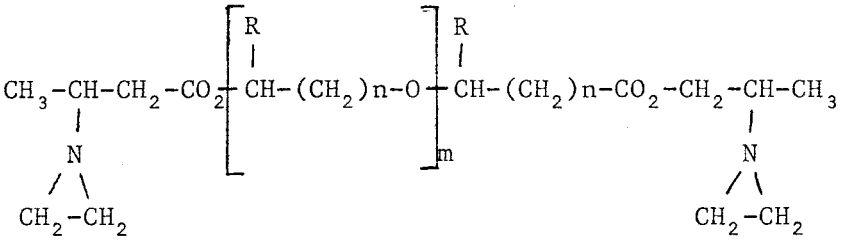
d) If an allergic skin reaction occurs, discontinue use of the material.

The viscosity and tear energy of polyethers made the impression difficult to withdraw intact. This characteristic was indignous to most gypsum products also. The manufacturer recommended a sufficient bulk of material between impression and tray to avoid this problem. In a study by Herport et al., (1978) polyether material displayed a tear resistance slightly higher than the silicones but one third to one fifth as high as the polysulfides. Also, it exhibited an acceptable viscosity during manipulation. However, "Impregum" polyether had a high shear modulus and mediocre tear resistance. The polyether system had a clean handling characteristic and a nice odor. The components noted:

Base: Cross-linked cationic polymer, polymerized by a ring opening of the imine which resulted in an increased molecular weight.

Catalyst: Alkyl benzone sulfonate and a glycol ether plasticizer.

Formula



Body modifier: Phthalate or a simple polyether with Silica added as a thickening agent to make a paste.[2,14]

Braden, Causton and Clarke[3] showed in a study, the material was clean handling, odorless, quick setting, but very viscous. Dimensional stability of polyether in air was very good, but the exposure to water affected it considerably. The same investigators also proved polyether was better than hydrocolloids because of its strength and dimensional stability.[3] They agreed with other researchers that the recommended setting time was shorter than polysulfides and because it had a high affinity for water.[3]

When polyethers were used to test the accuracy of stone dies reproduced from a master model, they routinely produced the most accurate dies.[4] The second most accurate dies were produced from a nonlead polysulfide.[4] The polyethers, silicones and polysuflides were called elastic materials because of their rubber-like qualities.[7]

Reisbick,[10] measured the effect of viscosity on the accuracy and stability of elastic impression materials. He stated: "If the

viscosity of the material is too low, the material will either run out of the tray or will not be held in intimate contact with the impression site. If the viscosity is too high, elastic strains may be induced which on release would result in a distorted and inaccurate impression."[10] It was obvious, viscosity was very important in the placement of the impression.[10]

Many authors such as Fairhurst et al., in 1956: Gilmore et al., in 1959; Sawyer in 1971; and others, found the manufacturer's recommended setting time was insufficient to allow the complete polymerization of impression materials.[11] This problem was avoided with the increase of the setting time over that recommended by the manufacturer.[11] As stated previously the polysulfides have a longer setting time than the silicones and polyethers.[13]

Materials for dental practice should be selected carefully. These impression materials should possess certain desirable properties:

1. accuracy
2. dimensional stability
3. adequate shelf life
4. tolerable setting time
5. patient acceptability
6. non-toxic
7. non-irritant

The polyether (Impregum) was the most resilient of all the elastomeric impression materials and it was hygrophillic. However, the expansion that occurs because of this absorption characteristic was offset by the extraction of water misable material from the rubber (Causton, Braden in 1971.[14])

Hannah and Pearson reported polyether material had more acceptable dimensional stability than other elastomers.[14] This characteristic will be the subject of the next chapter.

DIMENSIONAL STABILITY

Dimensional accuracy and stability of dental impression materials were a challenge for the entire profession.[9] Some factors which affected the dimensional accuracy of impression materials are:

1. Thermal effects:

During the time the material was in the patient's mouth, it was at open mouth temperature, and when removed cooled to room temperature. During these changes of temperature, each material was affected in a different way because the coefficient of thermal expansion was unique for each material.

When inserted in the mouth, the impression material was still plastic and its flow initially compensated for any difference at this stage. When they (material and tray) were rigid at the time of removal from the mouth, a differential contraction occurred. This could affect the model making, and the resultant die was smaller than the original tooth.[9]

2. Water absorbtion while taking the impression:

All elastic impression materials absorbed water from the tissues. This absorption caused a contraction or an expansion or both within the same impression.[9]

3. Elastic recovery effects:

The deformation should be reversible when withdrawn from undercut regions, and the material will have to return to a point of equilibration. When the equilibrium position was maintained the most accurate reproduction of the original resulted.[9]

4. Continuing Polymerization:

Anderson 1958, McLean 1958 and others, showed impression materials kept shrinking many hours after the impression had been taken. However, when elastic materials were removed from the mouth, they were usually rigid enough to resist permanent deformation. If the impression was in a rigid tray, this shrinkage after polymerization was towards the tray. The model which resulted from this impression will be larger than the original, which was of paramount importance to the dentist.[9]

5. Loss of Volatile Contituents:

If the set impression lost volatile contituents, a contraction was expected, and this resulted in a larger model than the original.[9]

6. Water absorption during storage:

Polyether, as well as other elastic materials, absorbed water from their environment during storage. Swelling from the tray and material also resulted in a smaller model than the original because of the shrinkage of the impression space.[9]

7. Setting expansion of the stone:

The expansion of the setting stone did not drastically affect the impression material itself. However, we had to consider it because it affected the accuracy of the final result of this impression.[9]

8. Expansion of the impression's surface:

At this point a swelling of the impression surface must be considered because this resulted in a smaller model, in comparison with the original.[9] Many of these effects occurred during the impression process, and it is impossible to isolate them because they were interrelated.

Polyethers possessed an exceptional dimensional stability. They were shown to be very stable in air and produce models which were very accurate. The polyethers have been shown to possess inherent elasticity. This behavior allowed the impression to recover from stress or deformation from handling, storage and/or shipping.[2] The polyether exhibited less than -0.1% of dimensional changes when stored in air for several hours.[2] However, immersion in water resulted in an initial expansion, followed by a contraction. The thiner sections of the impression were more severely affected.

Caustun and Braden suggested it was possible to have dimensional changes of high magnitude, because polyethers had a high water absorbing characteristic.[4]

Sawyer[4] suggested in a pilot study, polyether's dimensional stability wasn't usually permanently affected by moisture. However, Braden and co-workers demonstrated this material absorbed a large amount of water because of its water absorbing characteristics (hygrophilic).

Polyethers showed a slight weight gain when stored in normal room conditions. They also showed slight expansions.[9] This lent more credence to its hygrophilic properties. Polyethers, when compared with the other elastic impression materials, were the least affected by the strain accompanying their withdrawal from undercut regions. This material however, had to be kept in dry storage to retain its accuracy.[9]

Sawyer[8] studied the accuracy of stone casts produced from a master model. He found polyethers produced the most accurate casts, even if the pour was delayed for a week. They showed the smallest deviation from the master die. The casts didn't exhibit any significant dimensional change although a group was poured one week later than the control group.[8] There was another factor which affected the dimensional stability of elastic impression materials; this was the viscosity of the material.[10] If the viscosity was too low the material would run out of the tray or it would not be in contact with the impression site sufficiently long. If the viscosity was too high, elastic strains were induced. The result was a distorted impression.[10]

Impression materials were affected dimensionally by their

storage conditions. However, no material was completely stable.[11] Impregum, in Bells[11] study, showed the greatest dimensional change and water uptake in high humidity. However, the polyethers were still superior because of their high elastic recovery properties.[13] Dimensional inaccuracies were induced in the following stages of the manipulation:[14]

1) On insertion of the material into the mouth; at this time the material had to be able to resist plastic deformation.

2) During setting of the material; it was not accompanied by dimensional changes, standardized methods of stabilizing the tray were established.

3) Displacement from the tissue; in this stage two circumstances were important; adhesion of the impression to the tray, and ideally elastic behavior of the material were able to reproduce the undercuts accurately. If rigid materials were used they usually distorted on removal or even fractured.

4) Prior to the pouring of the impression; there was limited, predictable dimensional changes between the time the impression was removed from the mouth and poured.

5) Preparation of the model or die; the material had to be compabible with model and die material. The polyether had been reported to possess superior dimensional stability when compared to the rest of elastomers, (Hannah and Pearson, 1969).[14] In a study made by Kaloyanides,[17] he showed polyether materials had

much less permanent deformation than the mercaptan materials.[17] He stated a material did not regain its former shape once the values of the tensile forces passed the limit (elastic limit).[17]

MOISTURE EFFECTS

Polyethers suffered dimensional change due to their water absorbing characteristics; they had a demonstrable affinity for water (hygrophilic characteristic).[3]

Hembree and Nunez demonstrated moisture affected the polyethers dimensional stability.[5,4] Impressions were subjected to repeated contamination with moisture because of improper drying of a cavity preparation and/or by tissue seepage.[5]

Some dentists formerly stored impressions in a high humidity atmosphere before pouring them. This situation jeopardized the accuracy of the polyether material.[5] In order to use polyethers properly, contact with water had to be minimized. This water absorption characteristic was the biggest disadvantage of this specific impression material.[3] Because of all these reasons, the Council of Dental Materials and Devices recommended the storage of polyethers under dry conditions.[2]

Polyethers, as well as other type of impression materials, exhibited weight and dimensional changes if stored under different levels of humidity. Impregum proved to be the most affected by this condition and showed the greatest dimensional change and water uptake.[11] Polyether also was found to have a thermal expansion higher than other rubber materials. This was due to the low inorganic content it possessed.[3]

STONE DIE FABRICATION

Stone has a very important role in dentistry. Techniques have been developed for pouring impressions with minimum distortion. Stones were designed to reproduce as accurate as possible the teeth and soft tissue of the patient's mouth.

For this thesis, Vel Mix (Kerr) stone was used to pour the Impregum specimens. The accuracy of die stone was affected by the three dimensional changes of impression materials during its set and following withdrawal from the patient's mouth.[12]

It was assumed stone suffers a 0.05% expansion. Due to this fact, there were variations in length and diameter of dies.[12] For example; impressions made from elastomers had to be poured as soon as possible to prevent changes due to distortions. Impression materials suffered dimensional modification during the cooling phenomena, from the patient's mouth to room temperature, as well as evaporation of volatile elements and elastomer polymerization.

Hembree[1] noted polyethers can be poured three times, without drastically affecting the initial impression. It wasn't until the third repour when the material showed a significant difference at .05 level of significance between the control and the third repour.[1]

Sawyer et al., reported in a pilot study that polyethers were quite stable for 24 hours. They also stated polyethers were

not affected by an environment of 100% humidity. They believed the most accurate dies were produced from polyether impressions.[4]

In another study by Sawyer, one set of impressions were poured one week later. For this study three elastomer impression materials were used, and polyethers were shown to be the most accurate for the production of dies when measuring horizontal and vertical dimensions regardless of the time entered.[8]

When stone is set, an expansion can occur under the restraint of the material and the tray. This expansion was greater in areas of greater freedom. This reaction resulted in models which were larger than the initial impressions.[9]

Bell et al., recommended leaving impressions for about 30 minutes before pouring to allow elastic recovery to occur.[6] If there was a delay in the pouring of the impression, polyethers was shown to be the most stable over long periods if dry conditions prevailed.[6]

Bell stated, second pour casts were not as accurate as the first casts. He recommended the use of this second pour only for articulation.[6]

Humidity, therefore, affected the accuracy of polyether impression materials, hence the cast was affected as well.

METHODS AND MATERIALS

A polyether impression material manufactured by ESPE GmbH., Seefeld/Oberbayern, Germany and called Impregum, was tested. This material was used in its normal consistency without any body modifier. Four different tests were made and specimens were prepared for the experiments at room conditions using a stainless steel round die. (Fig. 1)

This round die had two vertical lines which were used to determine the accuracy of the impressions, and 3 horizontal lines that provided us with a guidance. The distance between the vertical lines was found to be 2.4989 cm. It had a highly polished surface to eliminate the need for a separator. With this type of surface it was possible to minimize cleaning operations which resulted in damage to the ruled surface. The die had a ring which was used as a tray or container for dental impression materials. (Fig. 2) Impregum was mixed using the manufacturers instructions and taken from a fresh batch. Prior to the mixture, base and catalyst were weighed on a Cent-o-gram triple beam (±0.059) balance model 311 (Ohaus Scale Corporation), using the proportion 1:0.14 base-catalyst. After mixing was completed, the material was placed in the die and with the ring in place, a glass plate was pressed against the material and the die, with a thin cellophane sheet in between. The glass, cellophane, and die were maintained in position together using a "C" clamp. (Fig. 3) The temperature was

recorded in the room with a glass thermometer, and the relative humidity was recorded with a Micro hygrometer, (The Microhygrometer by Air Guide). Finally, the time was measured by the use of a Chronometer.

After mixing, the material was introduced to a water bath. This bath was a full visibility jar bath, Blue M (Blue M Electric Company, Blue Island, Ill.) and it was filled with deionized water. When the material had set, the readings were made with the use of a Gaertner Traveling Microscope (The Gaertner Scientific Corporation, Chicago, Ill.), graduated in a 0.01 mm increments with a magnification of 32 X. (Fig. 4)

Method

The die was calibrated by making several measurements of the die. The calibration was found to be 2.4989 cm. Several specimens were made to improve the mixing, setting, and reading techniques. The impression material was then weighed and mixed according to the manufacturer's instructions. All precautions were taken to avoid bubbles, a homogenous mix was developed with a regimented mixing technique. The mixing was done on the pad the manufacturer provided for this purpose. After the weighing and mixing, the material was placed in the die (with the ring). It was then covered with cellophane for easy removal from the glass slab which was covered and held together with the "C" clamp.

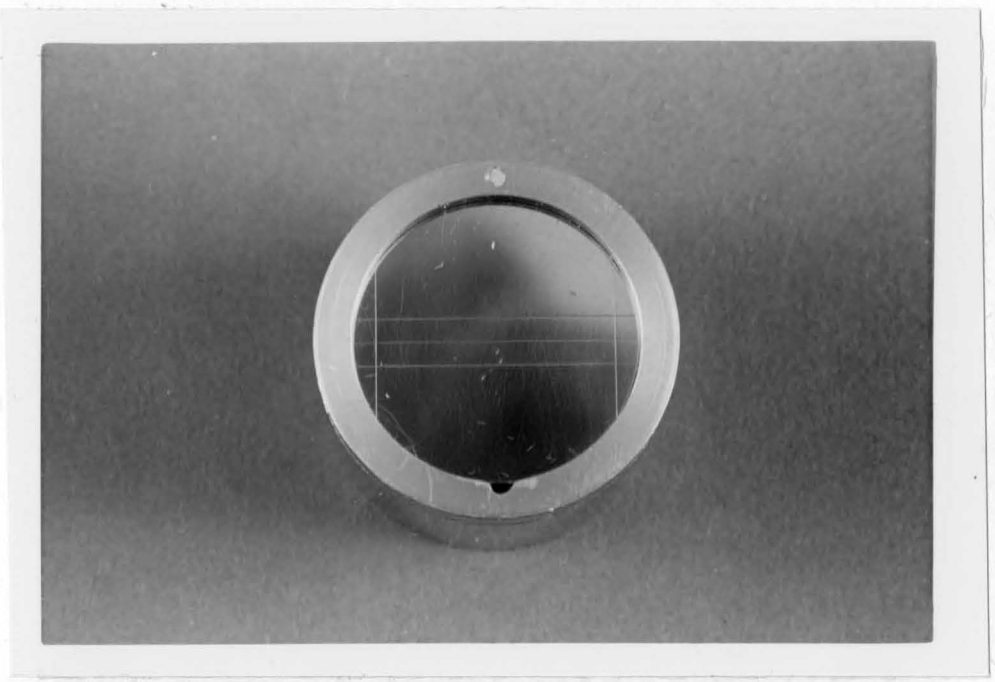


Fig. 1. Stainless steel round die ready to be used as a tray.

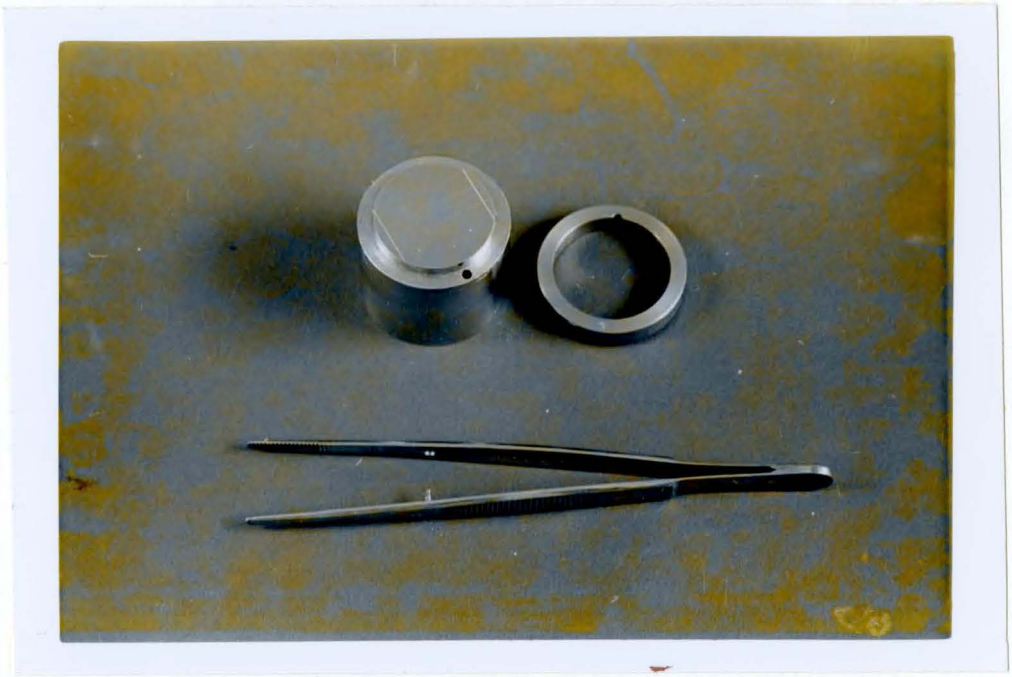


Fig. 2. Stainless steel round die unassembled.

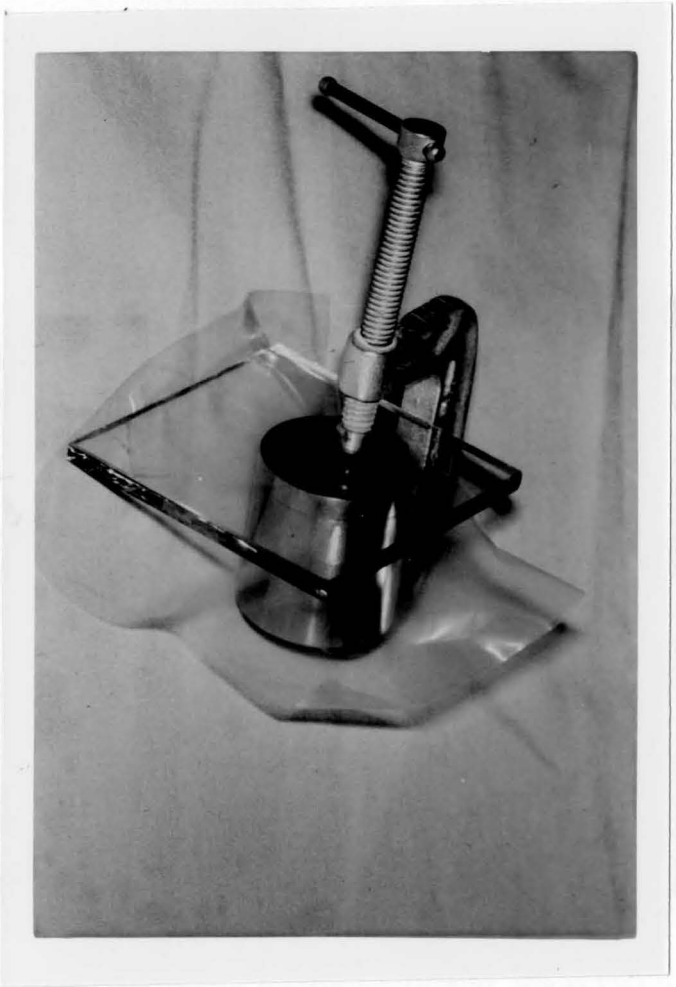


Fig. 3. "C" clamp maintaining glass, cellophane and die together.

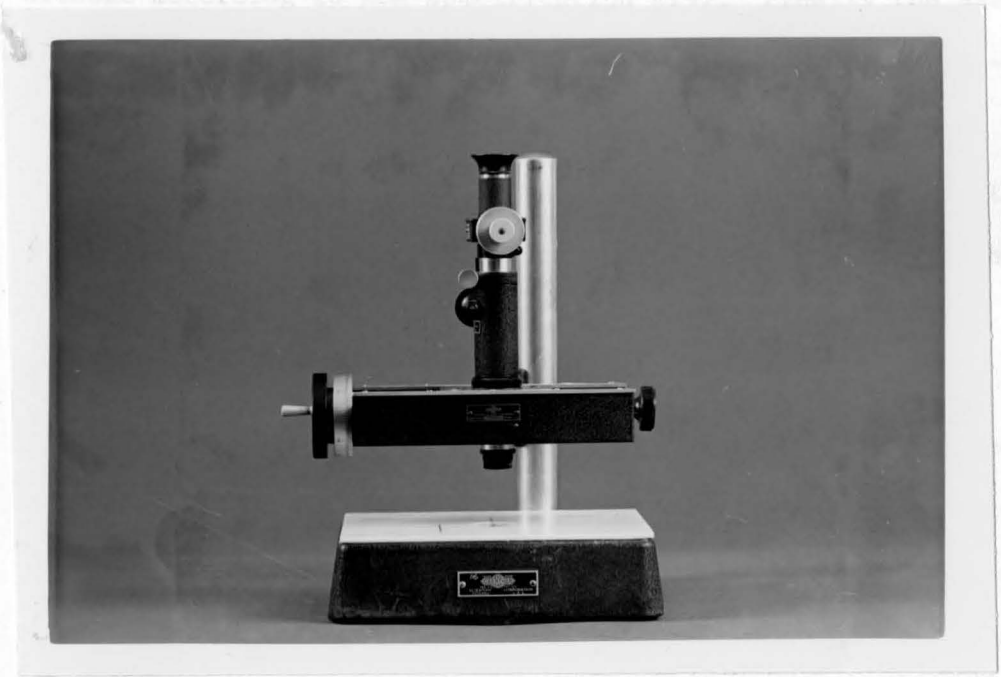


Fig. 4. Gaertner traveling Microscope (The Gaertner Scientific Corporation, Chicago, Ill.)

The next step was to introduce the assembly to the water bath at 32°C, 2.5 min. after the mix was started. The specimens were removed from the bath 6 min. later (the time was increased according to ADA specification #19). Finally the specimens were removed very carefully from the die to avoid discrepancies that could affect the accuracy of the impression. The specimen was then placed on the Gaertner microscope to start the readings. Four different conditions were selected for this investigation and the description of each is outlined below. (Fig. 5)

The first test was conducted at ambient conditions. Measurements for dimensional stability and accuracy of the material were made. For this test five specimens were used. The measurements were made 10 min. after finishing the mix, 1 hr. later, 24 hours, 48 hours and finally 1 week.

The second test was conducted at room temperature. After the specimens had completed their set, they were measured and placed in a water bath at room temperature. Measurements were made one hour following immersions as well as 24 hours later. After this 24 hour period, the specimens were withdrawn from the water and left in ambient conditions. Measurements were recorded after 48 hours and finally one week later. Five samples were used for this test.

For the third test, five specimens were used. Ten minutes after mixing the specimens were measured and then placed in 100%

humidity. They were measured at one hour and at 24 hours at 100% humidity. The five specimens were withdrawn from the humidity chamber and stored under ambient conditions and remeasured at 24 hrs, 48 hrs, and 1 week.

The fourth and last test was conducted as follows: eight impressions were made and measured after 10 minutes from the start of the Mix. Vel Mix stone was subsequently poured on the specimens. Thirty minutes later, stone was removed and measurements were made on the impressions and stone dies. One week later another measurement of samples was made. During ambient conditions storage, talc was used to prevent any deformation while contact of the specimens with other surfaces; also talc was used on the base of the microscope.

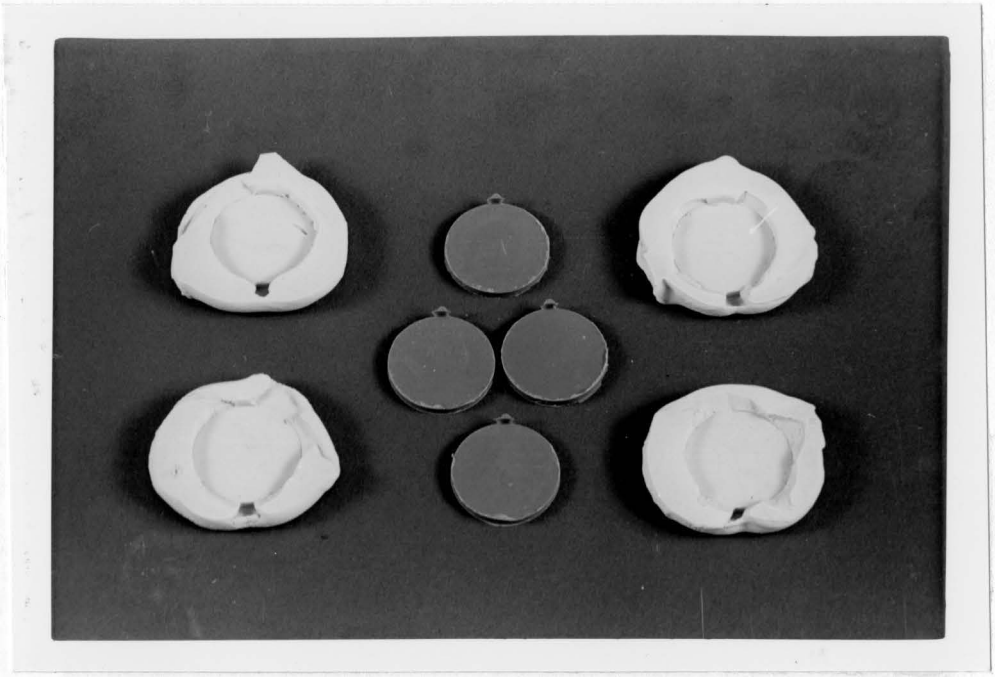


Fig. 5. Four Impregum specimens and pour Vel Mix die stone specimens.

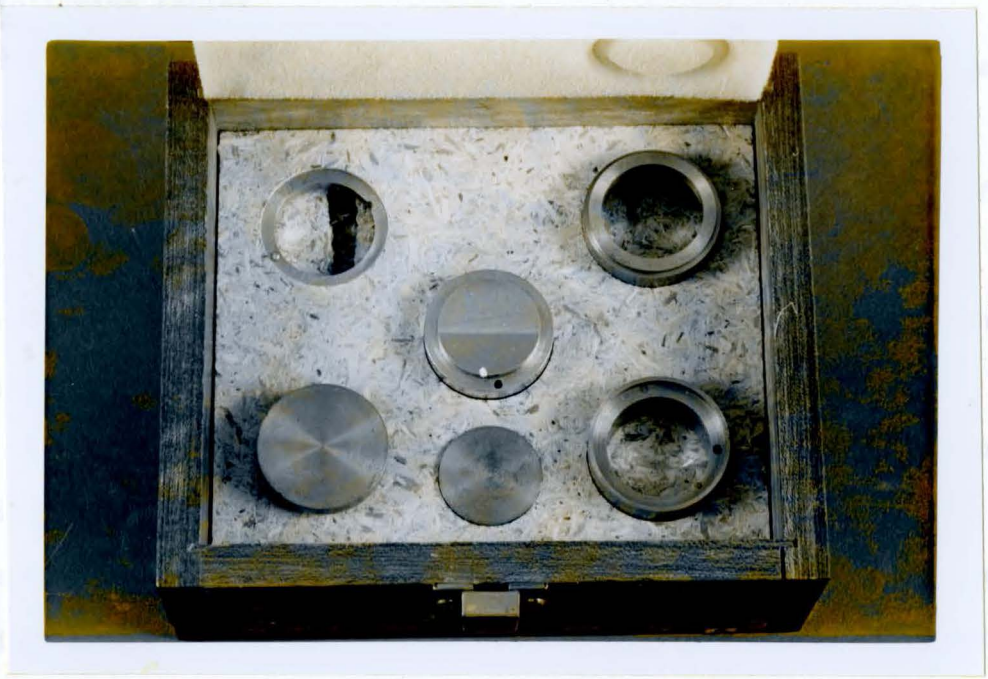


Fig. 6. Stainless steel round die kit.

RESULTS

The dimensional changes of the polyether impression material, at different times and levels of moisture are indicated in the following tables.

Table I shows the shrinkage the impression material undergoes when stored under dry conditions.

Table II shows the expansion the impression material suffers by means of submerging it in a water jar at room temperature. However, after withdrawn from water, the material undergoes a contraction.

Table III shows the expansion the impression material suffers during its storage in a humidor at 100% humidity environment. However, as in the case of the water jar, after the impression material is withdrawn from the humidor, it returns to its near original dimensions.

Table IV shows the expansion of the impression material when poured with Vel Mix die stone after its setting time (30 minutes). This reaction is apparently reversible when left dry at room conditions.

The polyether impression material was tested under the same conditions at room temperature and various levels of humidity. The material was also placed in a water bath at 32°C during setting to simulate the patient's mouth temperature while taking the impression. The results demonstrated the high hygrophilic characteristics

of this material. The time the manufacturer recommended to leave the impression in the mouth was increased according to ADA specifications #19 of Material and Devices.

If more information concerning a statistical evaluation of the results are required, the reader should turn to the appendix (page 41).

Table I

Accuracy and dimensional stability of Impregum impression material according to ADA specification #19

Mean Percentage deviation from the master die (2.4989 mm)

No.*	Time**				
	10 minutes	1 hr	24 hrs	48 hrs	1 week
1	.15	.13	.12	.13	.12
]	.16	.15	.12	.15	.14
3	.13	.15	.09	.13	.12
4	.14	.15	.12	.15	.15
5	.14	.15	.12	.15	.17
Mean	.14	.15	.12	.15	.14
St.dev.	± .0002	± .0002	± .0003	± .0005	± .0005

* All deviations in this table are contractions (-).

** Measured from the beginning of spatulation.

Table II

Accuracy and dimensional stability of Impregum impression material stored under water

Mean percentage deviation from the master die (2.4989 mm)

No.	Time*				
	10 minutes**	1 hr	24 hrs	48 hrs***	1 week
1	- .14	+ .16	+ 2.63	+ .23	- .14
2	- .14	+ .12	+ 2.39	+ .18	- .20
3	- .14	+ .16	+ 2.49	+ .27	- .18
4	- .11	+ .16	+ 2.66	+ .12	- .26
5	- .12	+ .15	+ 2.68	+ .18	- .32
Mean	- .13	+ .15	+ 2.57	+ .20	- .22
St.dev.	± .0004	± .0005	± .026	± .0031	± .0014

* Measured from the beginning of spatulation.

** Control measurements performed prior to insertion in water.

*** Measurements made on dry specimens that had been initially immersed in water for 24 hrs.

Table III

Accuracy and dimensional stability of Impregum impression material stored at 100% humidity

Mean percentage deviation from the master die (2.4989 mm)

No.	Time*				
	10 minutes**	1 hr	24 hrs	48 hrs***	1 week
1	- .16	+ .03	+ 1.36	+ .21	+ .14
2	- .17	- .008	+ 1.41	+ .18	+ .02
3	- .12	+ .22	+ 1.27	+ .19	+ .02
4	- .13	- .04	+ 1.49	+ .17	+ .06
5	- .13	+ .03		+ .20	+ .15
Mean	- .14	+ .03	+ 1.39	+ .19	- .01
St dev.	± .0006	± .0028	± .0023	± .0003	± .002

* Measured from the beginning of spatulation.

** Control measurements performed prior to insertion in 100% humidity.

*** Measurements made on dry specimens which had been initially immersed in 100% humidity for 24 hrs.

Table IV

Accuracy and stability of Impregum impression material when poured with Vel Mix die stone

Mean percentage deviation from the master die (2.4989 mm)

No.	Time*			
	10 minutes**	30 minutes	1 week	stone die***
1	- .11	+ .05	- .17	+ .02
2	- .18	+ .15	- .18	+ .06
3	- .14	+ .14	- .25	+ .05
4	- .09	+ .14	- .12	+ .02
5	- .04	+ .20	- .16	+ .38
6	- .08	+ .22	- .11	+ .06
7	- .06	+ .25	- .20	+ .10
8	- .07	+ .16	- .23	+ .08
Mean	- .10	+ .16	- .18	+ .10
St.dev.	± .0014	± .0015	± .0012	± .0029

* Measured from the beginning of spatulation.

** Control measurements prior to pouring with Vel Mix die stone.

*** This die was made from the Impregum impression (control 10 min) and measured 30 minutes after the beginning of spatulation.

DISCUSSION

A polyether impression material (Impregum) was tested for accuracy and dimensional stability. Four different tests were made at different levels of moisture to measure the effect on dimensional stability due to the hygrophilic characteristics of the material. Results are listed in tables I, II, III, and IV.

A stainless steel round die was used to prepare specimens for testing. Base and catalyst were weighed according to manufacturers instructions. After mixing, the material was placed on the die and the assembly was placed in a water bath at 32°C to simulate mouth conditions. After setting, the material was measured at various intervals in a Gaetner traveling microscope. Control specimens were measured at 10 minutes (from the beginning of the mix), 1 hr, 24 hrs, 48 hrs and one week. These measurements were then statistically compared to measurements taken from specimens subjected to the various levels of moisture contaminations. The dimensional stability of Impregum measured at standard conditions (ADA specification procedures) was found to be excellent for the entire time period of one week and was of the order of -0.015%. However, specimens that had been immersed in water for 24 hours showed an expansion of 2.5%. This expansion was shown to be reversible when the specimens were withdrawn from the water. The material contracted more than the control at an equivalent time period of one week. The phenomena can be due to

the loss of soluble material from the specimens.

Specimens were introduced in a humidor at 100% humidity environment. During the storage of the impression material in this environment a considerable expansion was also noted. However, after withdrawal from the humidor the material exhibited a reversible contraction which was not as extreme as the former water test. Since it was shown that moisture contamination of Impregum impression material had a profound effect on accuracy, a study was conducted to determine what effect would be observed when die stone was poured on the material. A mean expansion of 0.16% was observed 30 minutes after the die stone was poured against the impression material. However, measurements of the resultant dies that were prepared from this experiment showed an expansion of 0.10% when compared to the master die. This latter value compares favorably with normal setting expansion of gypsum die materials. It could be concluded that the expansion expected due to the water contamination from the die stone slurry was offset by the small normal setting contraction (-0.15%) of the impression material. The expansion of 0.10% observed on the set die therefore was due to the combined effects of: 1. the setting contraction of the impression material (-0.15%), 2. the setting expansion of gypsum die material (+0.07 to 0.10%), and 3. the expansion of the impression material due to water contamination from the die stone slurry (+0.15% by difference).

The calculated value of +0.15% expansion due to die stone slurry is of the same order of magnitude as observed when the impression material was exposed to water. It could be concluded the effect of moisture contamination due to die stone slurry will be no greater than the normal setting contraction of the polyether material. However, this will result in expansion rether than contraction. This factor may aid the dentist favorably since the overall expansion will result in slightly larger (+0.05%) dies. However, the results are similar to the water and humidity experiments. This expansion is also reversible. The results of this investigation are in full agreement with Hembree and Nunez in 1974.[5] However, their recommendation regarding storage of impressions in a high humidity atmosphere before pouring them was with little foundation.

Impregum has a great dimensional change and water uptake if stored in presence of humidity. This study confirmed the former statement and is in agreement with Bell, Davies and Fraunhofer,[11] who in 1976 stated Impregum was the most affected material when stored under a moist environment. Chong and Docking in 1969,[13] also stated polyethers had high elastic recovery properties which made them superior to other elastic impression materials.

The selection and design of the method for the realization of this research was developed to reproduce as much as possible a clinical situation in a dental office. If consideration is

taken concerning factors such as: 1. water absorption from the material when taking the impression; 2. levels of moisture during storage; 3. elastic recovery effect of the material; 5. setting expansion of the material; 6. relative humidity and temperature while the impression is taken; 7. base-catalyst proportion, etc., then following recommendations are forwarded as guidelines for proper manipulation of polyether impressions:

1. Equal proportions of impression material during spatulation, and the use of a proper mixing technique.
2. An adhesive should be applied to the tray (a custom tray should be used whenever possible) at least 20 minutes prior to the impression.
3. Isolate and dry teeth and adjacent tissues prior to insertion of the impression material.
4. Increase the setting time in the mouth of the material to insure it is fully set when withdrawn from the mouth.
5. Keep the impression under a dry environment till pouring.
6. Second casts should be used for positioning or temporization (margins should be finished on the first poured die).
7. Follow ADA specifications for the use of polyether impression materials.

Future research is recommended with the use of the adhesive the manufacturer provides, to reproduce a more clinical evaluation of the material.

SUMMARY

A polyether impression material called Impregum was tested for accuracy and dimensional stability.

After setting in a water bath at 32°C (to simulate a clinical situation), the material was subjected to four different environments:

1. The material was tested at room temperature. Measurements were made after 10 minutes, 1 hr, 24 hrs, 48 hrs and one week after setting.
2. The material was submerged into a water jar at room temperature. The measurements were conducted in the same manner and time intervals.
3. The material was placed in a humidifier at room temperature and again measurements were recorded at 10 minutes, 1 hr. 24 hrs, 48 hrs and one week after setting.
4. Finally, Vel-Mix stone dies were made from the Impregum impression specimens immediately after its initial set. Measurements of the material and the stone were then conducted.

Results demonstrated polyethers have hygrophilic characteristics. The material behaved in a superior manner in the air environment.

Polyethers were extremely accurate and showed an outstanding dimensional stability under dry conditions. However, under different levels of moisture, they suffered expansions due to their water absorptions characteristics.

At room conditions, after 10 minutes, the material illustrated its maximum accuracy. Conversely, all specimens suffered a contraction as time elapsed. The one week specimens showed the least desirable dimensional stability.

Under different levels of moisture, the material expanded instead of suffering a contraction. This was due to greater moisture in full water immersion than in the humidifier.

After pouring the stone into the impression material, the dimensional stability of the Impregum was measured, the results showed an ititial expansion due to the hygrophilic properties of the material. However, after one week's time, without contact with the stone, the impression material returned to approximately its original readings.

APPENDIX

Conditions	Mean	Standard deviation	"T" Value	Probability*
Air 10 min Air 1 hr	2.4953 2.4952	0	.74	.500
Air 10 min Air 24 hrs	2.4953 2.4960	0 0	-6.90	.002
Air 10 min Air 48 hrs	2.4953 2.4954	0	-0.31	.773
Air 10 min Air 1 week	2.4953 2.4954	0 .001	-0.07	.945
Air 1 hr Air 24 hrs	2.4952 2.4960	0 0	-3.97	.017
Air 1 hr Air 48 hrs	2.4952 2.4954	0 0	-1.43	.227
Air 1 hr Air 1 week	2.4952 2.4954	0 .001	-0.65	.552
Air 24 hrs Air 48 hrs	2.4960 2.4954	0 0	5.71	.005
Air 24 hrs Air 1 week	2.4960 2.4954	0 .001	2.88	.045
Air 48 hrs Air 1 week	2.4954 2.4954	0 .001	0.13	.903
Water 10 min Water 1 hr	2.4956 2.5026	0 0	-31.95	.000
Water 10 min Water 24 hrs	2.4956 2.5631	0 .003	-52.10	0

* If value is less than 0.05 the difference is statistically significant.

Conditions	Mean	Standard deviation	"T" Value	Probability*
Water 10 min	2.4956	0	-11.26	0
Water 48 hrs	2.5038	.001		
Water 10 min	2.4956	0	2.47	.069
Water 1 week	2.4934	.002		
Water 1 hr	2.5026	0	-48.60	0
Water 24 hrs	2.5631	.003		
Water 1 hr	2.5026	0	-2.00	.116
Water 48 hrs	2.5038	.001		
Water 1 hr	2.5026	0	11.62	0
Water 1 week	2.4934	.002		
Water 24 hrs	2.5631	.003	34.51	0
Water 48 hrs	2.5038	.001		
Water 24 hrs	2.5631	.003	36.71	0
Water 1 week	2.4934	.002		
Water 48 hrs	2.5038	.001	17.27	0
Water 1 week	2.4934	.002		
Hum. 10 min	2.4953	.001	-4.67	.010
Hum. 1 hr	2.5001	.003		
Hum. 10 min	2.4953	.001	-30.79	0
Hum. 24 hrs	2.5335	.002		
Hum. 10 min	2.4953	.001	-25.62	0
Hum. 48 hrs	2.5036	0		
Hum. 10 min	2.4953	.001	-2.36	.078
Hum. 1 week	2.4986	.003		
Hum. 1 hr	2.5001	.003	-13.18	.001
Hum. 24 hrs	2.5335	.002		

* If value is less than 0.05 the difference is statistically significant.

Conditions	Mean	Standard deviation	"T" Value	Probability*
Hum. 1 hr Hum. 48 hrs	2.5001 2.5036	.003 0	-3.23	.032
Hum. 1 hr Hum. 1 week	2.5001 2.4986	.003 .003	.90	.418
Hum. 24 hrs Hum. 48 hrs	2.5335 2.5036	.002 0	24.10	0
Hum. 24 hrs Hum. 1 week	2.5335 2.4995	.002 .002	19.12	0
Hum. 48 hrs Hum. 1 week	2.5036 2.4995	.002 .002	19.12	0
Stone 10 mm Stone 30 min.	2.4965 2.5030	.001 .002	-12.92	0
Stone 10 min Stone 1 week	2.4965 2.4932	.001 .004	2.21	.063
Stone 10 min Stone	2.4965 2.5013	.001 .003	-5.35	.001
Stone 30 min Stone 1 week	2.5030 2.4932	.002 .004	6.52	0
Stone 30 min Stone	2.5030 2.5013	.002 .003	1.70	.133
Stone 1 week Stone	2.4932 2.5013	.004 .003	-3.52	.010
Air 1 week Water 1 week	2.4952 2.5026	0 0	-40.72	0

* If value is less than 0.05 the difference is statistically significant.

Conditions	Mean	Standard deviation	"T" Value	Probability*
Air 1 week	2.4952	0	2.35	.079
Hum. 1 week	2.5001	.003		
Air 24 hrs	2.4960	0	-46.70	0
Water 24 hrs	2.5631	.003		
Air 24 hrs	2.4960	0	-29.86	0
Hum. 24 hrs	2.5335	.002		
Water 24 hrs	2.5631	.003	18.69	0
Hum. 24 hrs	2.5335	.002		
Air 1 week	2.4954	.001	3.62	.022
Water 1 week	2.4934	.002		
Air 1 week	2.4954	.001	-3.18	.033
Hum. 1 week	2.4986	.003		
Air 1 week	2.4954	.001	1.53	.200
Stone 1 week	2.2925	.005		
Water 1 week	2.4934	.002	-9.49	.001
Hum. 1 week	2.4986	.003		
Water 1 week	2.4934	.002	.55	.609
Stone 1 week	2.4925	.005		
Hum. 1 week	2.4986	.003	4.08	.015
Stone 1 week	2.4925	.005		
Die	2.4989	.007	14.07	0
Total mean 10 min.	2.4958	.004		

* If value is less than 0.05 the difference is statistically significant.

Conditions	Mean	Standard deviation	T. Value	Probability*
Die	2.4989	0	33.06	0
Air 10 min	2.4953	0		
Die	2.4989	0	37.92	0
Air 1 hr	2.4952	0		
Die	2.4985	0	22.13	0
Air 24 hrs	2.4960	0		
Die	2.4989	0	31.58	0
Air 48 hrs	2.4954	0		
Die	2.4989	0	31.58	0
Air 1 week	2.4954	0		

* If value is less than 0.05 the difference is statistically significant.

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science in Oral Biology.

April 12, 1978
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