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Research Article

COMPARATIVE EVALUATION OF DIMENSIONAL STABILITY AND SURFACE HARDNESS OF THREE ELASTOMERIC INTEROCCLUSAL RECORDING MATERIALS AT VARIOUS TIME INTERVALS - AN INVITRO STUDY

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INTRODUCTION

Diagnosis and treatment of a patient for a prosthetic rehabilitation requires the clinician to fabricate diagnostic casts, as well as master casts and articulate them on an articulator. For this reason it is necessary to record maxillomandibular relationship and accurately transfer it to the articulator. Correct interocclusal records give the clinician the opporunity to make only minimal adjustments to the prostheses that were delivered from the laboratory which will avoid unnecessary use of chairtime or repetitions. Errors in the clinical stage may be due to the biologic characteristics of the stomatognathic system or to mishandling of the interocclusal recording medium by the clinician.[1]

An ideal interocclusal registration material should provide minimal resistance to mandibular closure during the registration of maxillomandibular relationship to avoid distortion of the soft tissue and /or displacement of the mandible and should allow a reasonable length of manipulation time.when the viscosity of the polymerizing occlusal registration material remains low. Once placed, it should polymerize to a degree of rigidity that allows its removal from the mouth without distortion. The material should reproduce details of the registration and be dimensionally stable over time, so that subsequent use of interocclusal registration is used to relate the position of the dental casts on an articulator, it should be rigid enough to resist distortion that might result from the weight of the dental cast and the components of the articulator.[2]

Many materials like wax, acrylic resin, zinc oxide eugenol pastes, modelling compound and plaster and different techniques have been used for maxillomandibular registration procedures.[3] The introduction of elastomers, polyvinylsiloxane polyether and dimethacrylate to record interocclusal relationship is growing in popularity in the dental clinic, but it has made clinicians unsure which material they should use because most information available to guide the clincians in making interocclusal records focuses on the clinical techniques and methods involved and there is little objective information regarding use of interocclusal materials.[4]

Although few studies have been made of the accuracy and stability of the jaw relation registration materials. The purpose of this investigation was to examine the dimensional stability and surface hardness of three interocclusal recording materials in a controlled laboratory environment over period of time.[5]

MATERIALS AND METHOD

In this study a stainless steel die was prepared according to the ADA specifications no 19. Die consist of ruled block and mold. Ruled block was scored with 3 horizontal and 2 vertical lines was used for impression making. The horizontal lines were as labeled 1, 2 and 3. The width of the horizontal lines were 0.02mm. Two cross-points at the intersection of the vertical lines with line 1 were marked as x and x^1 and will serve as the beginning and end points of measurements for dimensional stability.[6]

A total of 30 samples divided into 3 groups comprising of 10 samples in each group for three different interocclusal recording material. The groups were labelled as GROUP I, GROUP II and GROUP III respectively.(Figure 1)

Figure 1

GROUP I comprised of Addition Silicone, Imprint.
GROUP II comprised of Addition Silicone, Futar D.
GROUP III comprised of Polyether, Ramitec.

A total of 30 samples with 10 each for three different interocclusal recording materials were prepared. Measurement of the each samples were taken between the parallel lines x and x^1 by means of travelling microscope (stereomicroscope) with magnification of 10 x. (Figure 2) The distance between the two parallel reference lines x and x^1 was measured at two fixed points.

Figure 2

The mean of the two readings were taken and statistically analyzed. Readings were recorded for all the ten samples of each group at an interval of 1hour, 24 hours, 48 hours and 72 hours. Reading obtained were in units (micrometer) which were later converted to millimeter using the conversion formula mentioned below. The mean of two readings, the distance between the lines x and x^1 sample was compared to the corresponding measurement of standard stainless steel die measured under the travelling microscope.

The values obtained in micrometer (um) are converted to millimeter (mm) using the formula.

Millimeter (mm) = No of units (micrometer) eyepiece/eyepiece magnification x zoom magnification.

The change in the dimension was calculated by the formula.

Dimensional stability %=(X-Y)/X x 100

Where X is the standard measurement (mm) xx^1 on the die.
Y is the observed measurement (mm) xx^1 on the sample.

Evaluation of surface hardness

The same specimens were used for the surface hardness of interocclusal recording materials using shore hardness tester. For testing of the specimens the depth indicator was set to zero. A finger pressure was applied with the index finger to the indentor for 3 seconds and unit was lowered on the sample, until the presser foot was in full contact with the specimen. The hardness value was displayed on the Shore hardness tester as shown in the (Figures 3)

Four reading were taken on four different sites of the specimen and mean value was taken for statistical analysis.[7]

All samples were stored at room temperature. Each sample was measured for dimensional stability and surface hardness at 1hr, 24hrs, 48hrs and 72 hrs. Dimensional stability was measured by measuring the distance between the reference lines at 2 fixed points on the sample. The mean of the distance between reference lines in each sample was compared with the corresponding measurement on the standard stainless steel die under travelling microscope (stereomicroscope). Surface hardness was measured using same samples with shore hardness tester. Four readings was taken on four different sites of the sample and mean value was taken for statistical analysis.

Figure 3

RESULTS

The results were subjected to one - way ANOVA analysis to assess the significance of the difference among the 3 groups. Subsequent pair-wise comparisons were performed by Tukey's multiple post hoc. The study revealed that significant greatest shrinkage rate of all the materials appeared within the first 48 hrs after the manufacturer's specified setting time. Polyether was more dimensionally stable than two polyvinylsiloxane interocclusal recording material. The surface hardness significantly increased in all the three materials up to first 48 hrs. Later no significant change in the hardness of the materials was seen. Surface hardness of polyvinylsiloxane was more compared to polyether.

DISCUSSION

Interocclusal registrations used for mounting models on articulators are partly responsible for the occlusal quality and precision of the final prosthetic restorations. Accurate mountings can lead to restorations that require minimal occlusal modifications intraorally and consequent reduction of chairside clinical time.[8] Limitations during registration and transference stages of the maxillomandibular relationship are encountered due to variety of difficult intraoral and extraoral conditions, resulting in some errors in the interocclusal relationship of mounted casts. One of the causes of this occlusal inaccuracy attributable to the clinical stage of interocclusal registration is related to the properties of the interocclusal recording materials because they can critically affect the accuracy of the interocclusal registration, apart from the operator's clinical ability and the techniques followed.

Dimensional changes are also caused by the temperature, polymerization shrinkage, chemical reaction, stress and mechanical manipulation that occur during the procedures.[9]

Among the properties of an ideal interocclusal recording material (1) have reproductive accuracy, (2) be easy to handle ,(3) have a fair degree of hardness when set, (4) be rigid when set, and (5) offer no resistance to closure during the registration. Most of these materials and techniques, as well as their shortcomings, have been described before.[10]Among the properties the most important are dimensional stability, accuracy and surface hardness if these are taken into consideration, this avoids any discrepancies between the maxillomandibular registration and mounting of the casts.

A wide range of materials for recording interarch relationships include from baseplate wax, Aluwax and impression (modeling) compound, plaster of Paris, zinc oxide eugenol paste and acrylic resin has been used for interocclusal recordings to the most current elastomeric materials like polyvinylsiloxanes and polyether. Hence this in-vitro study was designed to evaluate and compare the dimensional stability and surface hardness of the three elastomeric interocclusal recording materials at various time intervals of 1 hr, 24 hrs, 48 hrs and 72 hrs. The above mentioned time intervals were based on the time required to carry the interocclusal records to distant laboratories or delay in the articulation of the casts in the laboratory.[11]

To assess the dimensional stability of elastomeric interocclusal recording materials, ADA specification no.19 prescribes a stainless steel die with linear pattern inscribed on it and a travelling microscope (stereomicroscope) to measure the dimensional change, fitted with 10 x magnification micrometer eyepiece were used in the present study. The mean of two readings were obtained which were later converted to millimeter using conversion formula as mentioned earlier. To measure the surface hardness, Shore A Durometer (RSK Co., Taiwan) was used.

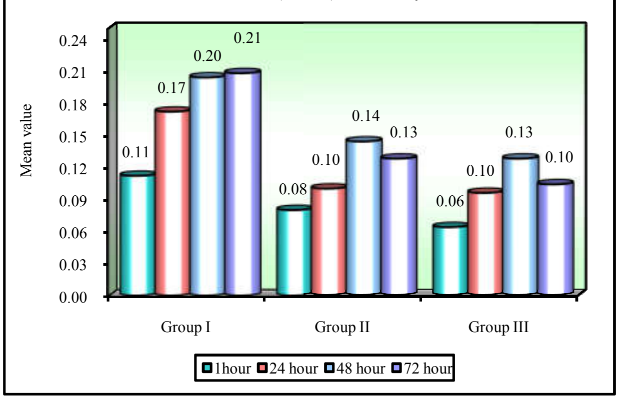
Statistical analysis of the difference in dimensions was done between the measurements obtained from stainless steel die and the specimens made of each interocclusal recording material (2 commercially available Polyvinylsiloxane and 1 brand of Polyether).The results were subjected to one - way ANOVA analysis to assess the significance of the difference among the 3 groups. Subsequent pair-wise comparisons were performed by Tukey's multiple post hoc.

The present study revealed that significant greatest shrinkage rate for all the materials appeared within the first 48 hrs of the manufacturer's specified setting time. A study done by Craig and Millistein as similarly noted at 24 hours.[11]

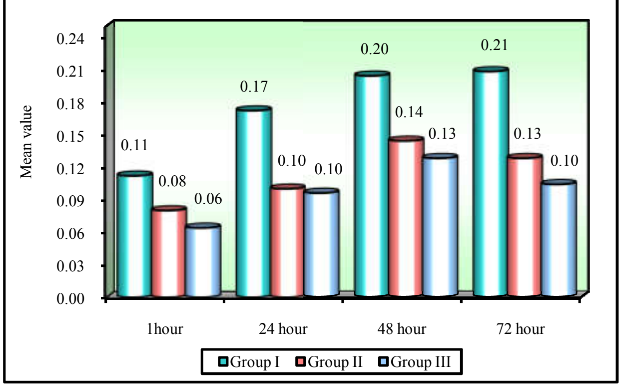
In the study among the three materials polyether was found to be the most accurate and stable material. Shrinkage was significant within the first 48 hours. A report by Craig on polyether contraction curve illustrated two important properties of the material namely, (1) polyether has a high coefficient of thermal expansion.[12] Therefore, there was contraction of the material as it cooled from the water bath to room temperature. This affected the immediate reading. (2) Polyether sets by a polymerization reaction .The setting time of the material as stated by the manufacturer and the completion of the reaction did not coincide. Distortion of the registration material resulted as the curing continued past the setting time.[13]The current data reflected no expansion of the polyether registration material. Instead the material exhibited contraction deformation, suggesting that polyether was a modification of the impression material. Craig and Peyton stated there was 0.3% shrinkage of polyether at the end of 24 hours. This concurred with results of the present study.[5]

In the present study all the three groups were compared by Tukey's post hoc test. Dimensional changes were noticed in both polyvinylsiloxane and polyether GROUP. Significant dimensional changes were more within first 48 hours when compared to 72 hours. It is also observed that GROUP I (polyvinylsiloxane) changes in the dimension was more compared to GROUP II (polyvinylsiloxane) and GROUP III (polyether) (GRAPH 2). Polyether interocclusal registration material exhibited significantly higher dimensional stability than the polyvinylsiloxane material tested.

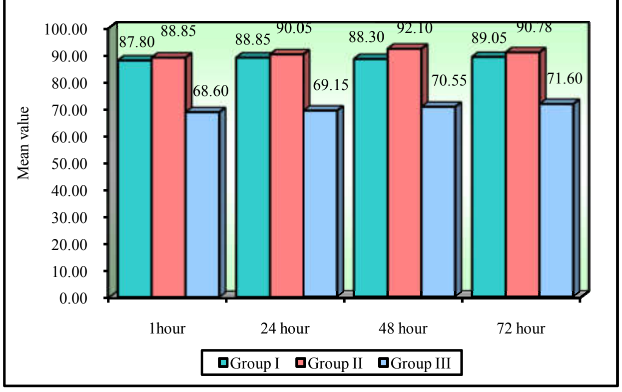
GRAPH 1:Comparison of 1hour, 24 hours, 48 hours and 72 hours in three GROUPS (I, II, III) with stability in xx1 line.



GRAPH 2: Comparison of three GROUPS (I, II, III) with stability in xx1 line at 1hour, 24 hours, 48 hours and 72 hours.



GRAPH 3: Comparison of three GROUPS (I, II, III) with surface hardness at 1hour, 24 hours, 48 hours and 72 hours .



Hardness of the interocclusal recording material at setting time is also critical, as it can ensure distortion free interocclusal recordings. Hard, highly filled inter-occlusal recording materials are expected to exhibit less vertical discrepancies due to reduced setting shrinkage and high resistance to deformation ensuring more accurate fit on stone models.[10]

In the present study both the groups of Polyvinylsiloxane interocclusal recording material (GROUP 1and GROUP 2) showed same surface hardness .whereas Polyether (GROUP 3) showed lesser values as compared to Polyvinylsiloxane interocclusal recording material.

When results of the present study was analyzed by pair wise comparison. GROUP II had surface hardness more than the GROUP I at 1 hour but was not statistically significant. There was statistically significant increase in hardness in GROUP I than GROUP III. The significant increase in the surface hardness was noticed in all the 3 materials up to first 48 hrs later no significant change in the hardness of the material was seen. These results are in accordance to similar study done by Hatzi et al.[10]

This is mainly attributed to substantial post-curing reactions in these materials, which exhibited the highest (GROUP I AND GROUP II) and the lowest (GROUP III) values. The former prove that conversion in materials with high unsaturation during the early setting stages, still proceeds at slow rate over time to reach equilibrium, whereas the latter highlights the fact that the chemistry of a system providing low unsaturation upon setting, still has the capacity of post-curing. Post-curing reactions may further strengthen the material to deformation, but also may increase total shrinkage and stiffness, that may create problems when positioning or repositioning the materials after storage.[10]

Hence with results of the following study it can be concluded that polyether was the most dimensionally stable interocclusal recording followed by polyvinylsiloxane (Futar D and Imprint) interocclusal recording material. Surface Hardness of the polyvinylsiloxane (GROUP I and GROUP II) was more superior than polyether.

CONCLUSION

Within limitations of the present study following conclusion can be drawn**.**

1. The dimensional stability decreased with increase in time and is influenced by both material factor and time factor.
2. Polyether was found to be more dimensionally stable interocclusal recording material, which was followed by polyvinylsiloxane (Futar D and Imprint)
3. Polyvinylsiloxane Imprint (Group I) is dimensionally less stable when compared with polyether (Group III) and polyvinylsiloxane Futar D (Group II).
4. We recommend that the polyether interocclusal records must be articulated immediately or within 1 hour or after 48 hours and Polyvinylsiloxane interocclusal records must be articulated within 1 hour or after 72 hours to get a correct restoration to have very minimum distortion and maximum satisfaction without failure of prosthesis.
5. Surface hardness of all the three groups increased over period of time, with both the groups of Polyvinylsiloxane showing the same surface hardness greater than polyether.

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