ORIGINAL RESEARCH

Linear Dimensional Changes of Five Interocclusal Recording Materials When Immersed in Two Disinfectants for Different Time Intervals

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Abstract

Aim: In this study, we intend to compare the linear dimensional changes of interocclusal recording media by immersing them in disinfectant solutions at different time intervals.

Materials and methods: Five interocclusal recording materials were used for this study and were grouped according to material types, namely wax, zinc oxide eugenol impression paste, polyether, polyvinyl siloxane, and bisacryl bite registration material. Each material was manipulated and injected into a stainless steel die. The materials were divided into 5 groups with 5 subgroups of 10 samples with a total of 250 samples. The samples were subjected to immersion in 2% glutaraldehyde and 0.5% sodium hypochlorite each for 30 and 60 minutes. Linear dimensional changes of the samples were tested by measuring the distance between points A and B at different time intervals by means of a stereomicroscope and compared with the control group.

Results: Bisacryl showed the least linear dimensional change when immersed in both the solutions.

Conclusion: Bisacryl (Luxabite) presented no linear dimensional change at both time intervals as opposed to the other materials, hence, it is most accurate.

Keywords: Glutaraldehyde, Interocclusal recording materials, Linear dimensional change, Sodium hypochlorite.

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Introduction

Prosthodontics deals with dental impressions and interocclusal registrations using impression materials and bite registration materials. These are sources of contamination and carry a great number of microorganisms on their surfaces, as they are in contact with saliva and blood. Effective infection control procedures in dental offices and dental laboratories will prevent cross-contamination between patients, dentists, dental office staff, and dental technicians.[1]

There are three levels of disinfection, namely high, intermediate, and low-level disinfectants. Disinfection in the form of ultraviolet (UV) and gamma radiation is another method followed.[2] Based on the type of chemical disinfectant, immersion and spraying methods are the two common methods available to disinfect dental materials. Immersion covers all surfaces for disinfection in one time, unlike spraying, which is incapable of disinfecting undercuts.[3]

Elimination of microorganisms by glutaraldehyde solution is by fixating cell membranes and blocking the release of cellular components. Action of sodium hypochlorite is based on cell oxidation by both oxidizing and hydrolyzing agents.[4]

Diluted hypochlorite solution has shown adverse effects on zinc oxide eugenol (ZOE) immersed for 16 hours. About 2% glutaraldehyde when used for immersion of polyether shows dimensional changes.

Glutaraldehyde, iodophor, and 0.5% sodium hypochlorite can be used to disinfect additional silicone.[5]

This study aims at evaluating and comparing the linear dimensional changes of five interocclusal materials, namely Aluwax, zinc oxide eugenol paste, polyether, polyvinyl siloxane, bisacryl when immersed in 2% glutaraldehyde, and 5% sodium hypochlorite disinfectant solution for a time interval of 10 and 60 minutes.

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Materials and Methods

The study was carried out at Sri Rajiv Gandhi College of Dental Sciences, and testing of the immersed samples after stipulated time according to subgroups was done at Analytical Research and Metallurgical Laboratories Private Limited. Materials used for sample preparation are Aluwax (Maarc), zinc oxide eugenol impression paste (DPI), Ramitec (3M ESPE, Germany), O-Bite (DMG, Germany), and Luxabite (DMG, Germany).

Armamentarium used are stereomicroscope, stainless steel mold, plastic syringe, stainless steel spatula, glass slab, automixing gun, polyethylene sheet, BP blade, and handle.

Preparation of Die

A stainless steel die was used to prepare the specimens (Fig. 1). The die consists of test block part A and ring mold—part B. The test block had two reference points, points A and B. The distance between these two points was 20.11 mm. The ring block was a cylinder of an inner diameter of 30 mm and a depth of 2 mm thickness.

Selection and Manipulation of Materials

Five commonly used interocclusal recording materials were selected for the purpose of this study. All the materials were purchased from local market through regular commercial channels. The distance between the reference points A and B reproduced on the samples of wax (Fig. 2), zinc oxide eugenol impression paste, (Fig. 3), polyether (Fig. 4), polyvinyl siloxane (Fig. 5), bisacryl (Fig. 6), and bite registration material was measured by using a stereomicroscope. Readings were obtained for each sample at different time intervals post disinfection, i.e., 10 and 60 minutes after removal from the die.

The materials used for this study were divided into five groups as:

- Group A: Aluwax (Maarc).
- Group B: zinc oxide eugenol impression paste (DPI).
- Group C: polyether bite registration material (3M ESPE, Germany).
- Group D: polyvinyl siloxane bite registration material (DMG, Germany).
- Group E: bisacryl bite registration material (DMG, Germany).

These 50 samples were subdivided into 5 subgroups, consisting of 10 samples each. All the samples (except the control group) were subjected to disinfection.

Fig. 1: Stainless steel die

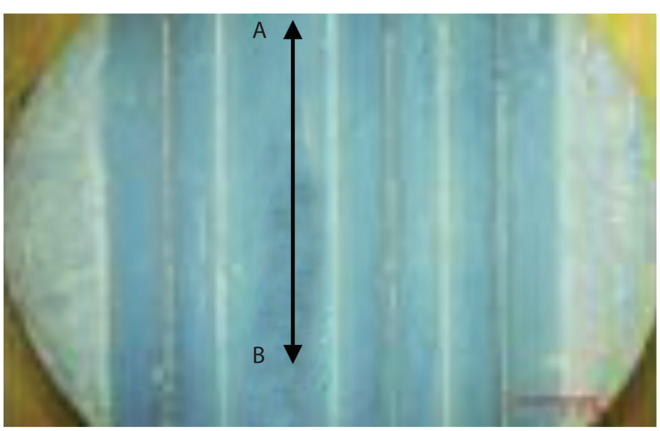

Fig. 2: The distance between reference points A and B reproduced on the samples of wax when viewed under the stereomicroscope

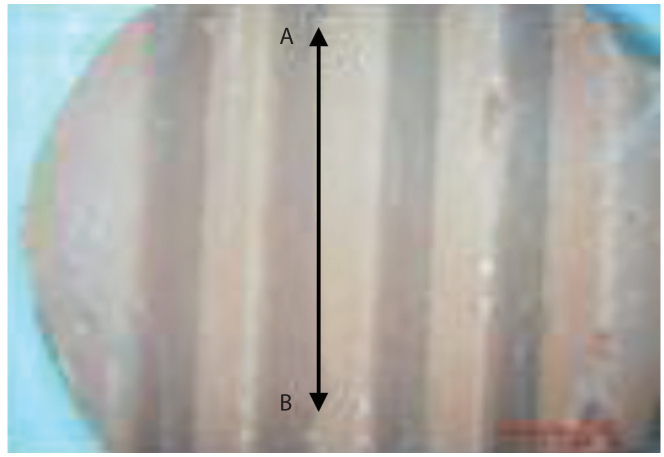

Fig. 3: The distance between reference points A and B reproduced on the samples of zinc oxide eugenol paste when viewed under the stereomicroscope

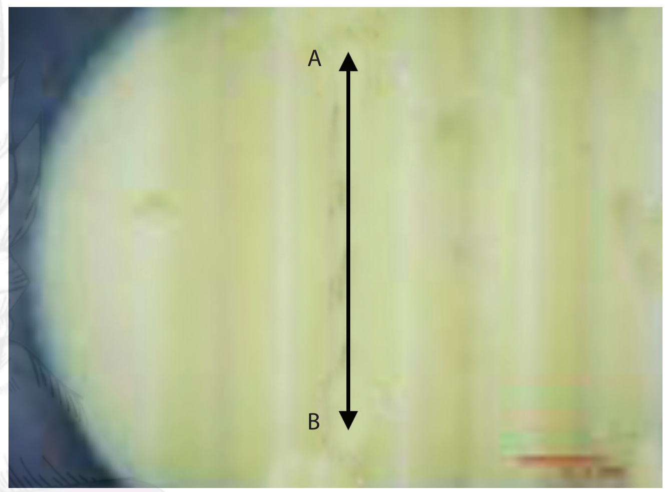

Fig. 4: The distance between reference points A and B reproduced on the samples of polyether when viewed under the stereomicroscope

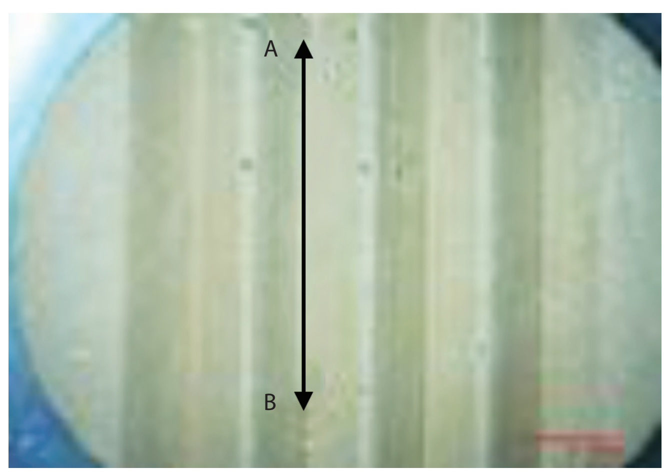

Fig. 5: The distance between reference points A and B reproduced on the samples of polyvinyl siloxane when viewed under the stereomicroscope

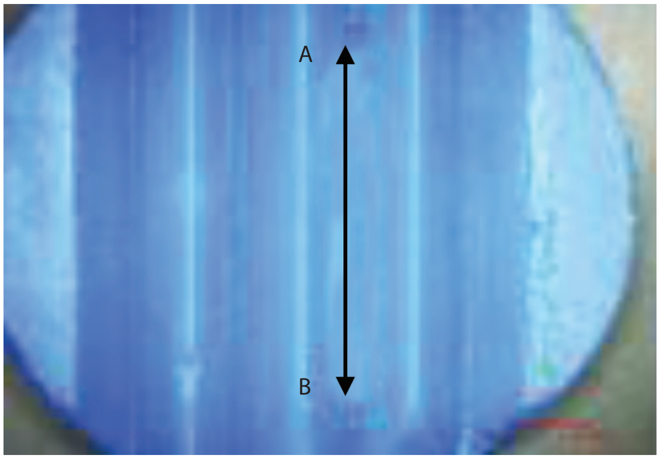

Fig. 6: The distance between reference points A and B reproduced on the samples of bisacryl when viewed under the stereomicroscope

The samples were subgrouped and immersed in glutaraldehyde and sodium hypochlorite for time intervals of 10 and 60 minutes into beakers. They were subgrouped as follows:

- Subgroup I: (control group): no disinfection.
- Subgroup II: immersion in 2% glutaraldehyde for 10 minutes.
- Subgroup III: immersion in 2% glutaraldehyde for 60 minutes.
- Subgroup IV: immersion in 5% sodium hypochlorite for 10 minutes.
- Subgroup V: immersion in 5% sodium hypochlorite for 60 minutes.

Manipulation of Wax Bite Registration Material (Aluwax)

Wax was manipulated by breaking it and putting it into a syringe before melting. A 5 mL syringe was submerged into a 45 °C water bath for 5 min. After homogenous mixing, the material was injected into the mold.

Manipulation of Zinc Oxide Eugenol and Polyether Bite Registration Material

The required amounts of equal lengths of base paste and catalyst paste were dispensed on the mixing pad provided by the manufacturer. These two pastes were mixed together with a stainless steel mixing spatula for 30 seconds to get a homogenous streak-free mix. The material was then spread on the surface of the stainless steel die by taking precautions not to incorporate any air bubbles.

Manipulation of Polyvinyl Siloxane and Bisacrylic Bite Registration Material

The polyvinyl siloxane bite registration was supplied in the form of a cartridge-containing base paste and accelerator paste. The cartridge along with a mixing tip was attached to an automixing dispensing gun. The material that expelled from the dispensing tip was uniformly spread over the surface of the stainless steel die by taking precautions not to incorporate any air bubbles.

Preparation of Samples

Each material was manipulated according to the manufacturer's instructions and dispensed on the die as mentioned above. After dispensing on the stainless steel die, a glass plate covered with a polyethylene sheet was placed on the stainless steel die over which a weight of 500 g was kept and the material was allowed to set for 5 minutes. Thus, a total force of 5.56 N (the weight of the glass plate is 67 g + external weight of 500 g) was applied. This was the average pressure required to compensate the initial resistance of the interocclusal material, which may vary between 0.5 N and 13.8 N. Each sample was separated from the die after 5 minutes. All the excess material (Flash) was trimmed by using a Bard Parker blade. The prepared specimens were measuring 30 mm in diameter and 2 mm in thickness. The materials were allowed to set for the manufacturer's suggested setting time plus an additional 3 minutes to ensure polymerization of the materials. Fifty samples were made from each group (a total of 250 samples from 5 groups).

Results

The distance between the reference points A and B reproduced on all the 250 samples of bite registration material was measured by using the stereomicroscope. Readings were obtained for each

Table 1: The comparison of the distance between reference points reproduced on the samples within the subgroups of wax interocclusal recording material using the ANOVA test

Groups	*Mean*	*Standard deviation*	*95% confidence interal for mean*		*F*	*p*
			Lower	*Upper*		
Subgroup 1	20.2780	0.00422	20.2750	20.2810	258.372	0.000 (HS)
Subgroup 2	20.2810	0.00738	20.2757	20.2863		
Subgroup 3	20.2380	0.00422	20.2350	20.2410		
Subgroup 4	20.2280	0.00422	20.2250	20.2310		
Subgroup 5	20.2780	0.00422	20.2750	20.2810		

Table 2: The comparison of the distance between reference points reproduced on the samples within the subgroups of zinc oxide eugenol paste interocclusal recording material using the ANOVA test

Groups	*Mean*	*Standard deviation*	*95% confidence interval for mean*		*F*	*p*
			Lower	*Upper*		
Subgroup 1	20.2280	0.00422	20.2250	20.2310	1511.495	0.000 (HS)
Subgroup 2	20.3680	0.00422	20.3650	20.3710		
Subgroup 3	20.2270	0.00483	20.2235	20.2305		
Subgroup 4	20.2760	0.00516	20.2723	20.2797		
Subgroup 5	20.2770	0.00483	20.2735	20.2805		

Table 3: The comparison of the distance between reference points reproduced on the samples within the subgroups of polyether interocclusal recording material using the ANOVA test

Groups	*Mean*	*Standard deviation*	*95% confidence interval for mean*		*F*	*p*
			Lower	*Upper*		
Subgroup 1	20.1870	0.00483	20.1835	20.1905	9064.716	0.000 (HS)
Subgroup 2	20.2280	0.00422	20.2250	20.2310		
Subgroup 3	20.5570	0.00483	20.5535	20.5605		
Subgroup 4	20.3260	0.00699	20.3210	20.3310		
Subgroup 5	20.1980	0.00422	20.1950	20.2010		

Table 4: The comparison of the distance between reference points reproduced on the samples within the subgroups of polyvinyl siloxane interocclusal recording material using the ANOVA test

Groups	*Mean*	*Standard deviation*	*95% confidence interval for mean*		*F*	*p*
			Lower	*Upper*		
Subgroup 1	20.1770	0.00483	20.1735	20.1805	12623.826	0.000 (HS)
Subgroup 2	20.2780	0.00422	20.2750	20.2810		
Subgroup 3	20.6070	0.00483	20.6035	20.6105		
Subgroup 4	20.2780	0.00422	20.2750	20.2810		
Subgroup 5	20.2970	0.00483	20.2935	20.3005		

Table 5: The comparison of the distance between reference points reproduced on the samples within the subgroups of bisacryl interocclusal recording material using the ANOVA test

Groups	*Mean*	*Standard deviation*	*95% confidence interval for mean*		*F*	*p*
			Lower	*Upper*		
Subgroup 1	20.2790	0.00316	20.2767	20.2813	1.144	0.348 (NS)
Subgroup 2	20.2810	0.00316	20.2787	20.2833		
Subgroup 3	20.2790	0.00316	20.2767	20.2813		
Subgroup 4	20.2780	0.00422	20.2750	20.2810		
Subgroup 5	20.2780	0.00422	20.2750	20.2810		

sample at different time intervals post disinfection, i.e., 10 and 60 minutes after removal from the die. All the readings thus obtained were tabulated (Tables 1 to 5) and subjected to statistical analysis for the comparison of linear dimensional changes of all five interocclusal recording materials.

Interpretation of Tables

Materials evaluated and compared in the present study were Aluwax (Maarc), zinc oxide eugenol paste (DPI), polyether (Ramitec), polyvinyl siloxane (O Bite), and bisacrylic bite registration material (Luxabite). Comparison of five groups (Tables 1 to 4) by the immersion technique for 10 and 60 minutes in both 2% glutaraldehyde and 5% sodium hypochlorite showed a highly significant difference in the mean values between the groups and subgroups when immersed for 10 and 60 minutes except for the bisacryl interocclusal recording material (Table 5) by the analysis of variance (ANOVA) test. The bisacryl interocclusal recording material showed no significant difference upon immersion in both solutions at both time intervals.

Contraction in the form of shrinkage occurs at 0.25% when immersed in sodium hypochlorite for 10 minutes. Contraction occurs at 0.2% when immersed in 2% glutaraldehyde for 60 minutes and expansion occurs at 0.02% when immersed for 10 minutes. Wax showed no linear dimensional changes after immersion in 2% glutaraldehyde solution for 60 minutes. It showed the maximum linear dimensional changes after using 2% glutaraldehyde when used as a disinfectant after immersion for 10 minutes. ZOE showed no linear dimensional changes after using 2% glutaraldehyde and 5% sodium hypochlorite as disinfectants after immersion for 60 minutes. Polyether showed the minimum linear dimensional change when using 5% sodium hypochlorite as a disinfectant after immersion for 60 minutes. The maximum dimensional change was observed after immersion for 60 minutes in 2% glutaraldehyde. Polyvinyl siloxane showed the maximum linear dimensional changes after immersion in 2% glutaraldehyde solution and minimum changes when immersed in 5% sodium hypochlorite both for 60 minutes. Bisacryl showed no linear dimensional changes when immersed in both solutions for the same time intervals. The result of this present study is in accordance with the finding of Gounder R who compared and measured the accuracy of Aluwax, polyvinyl siloxane, and polyether interocclusal recording materials with disinfection using 0.5% chlorhexidine gluconate, 1% sodium hypochlorite, and 2% glutaraldehyde using immersion and spray atomization techniques for 30 and 60 minutes, which are being clinically acceptable.

Discussion

Interocclusal recording materials are used to transfer the interocclusal relationship from a patient's mouth to the lab.[4] During the restorative phase of any dental treatment, good interocclusal record and the precise articulation of patient's diagnostic or working casts are a prerequisite for the fabrication of clinically acceptable prosthesis. Apart from the operator's clinical ability and the technique followed, the chosen material can affect the accuracy of interocclusal registration and, thereby, the final outcome of the restoration. Bite registration record acts as a significant source form of cross-contamination, so the American Dental Association (ADA) issued guidelines for disinfecting impressions in 1988, 1991, and 1996.[7] These must be disinfected immediately after their removal from the mouth. Since all dental materials have their inherent limitations, learning to minimize discrepancies in making jaw relation records is critical.

According to Pagnano et al., jaw relation records, or interocclusal records, have the following functions: (1) they provide the stability or support that the casts of the remaining dentition lack, (2) they reduce chair side time for the delivery of the restoration, (3) they reduce the likelihood of making restorations in hyperocclusion or without occlusal contacts, and (4) they reduce the chance of perforation of restorations being inserted with excessive adjustment or having to adjust the opposing dentition inappropriately.[8]

Rigid materials, such as resins or waxes, should be used only for segmental records and not for full arch interocclusal records because they could cause an inadvertent increase in the vertical dimension of occlusion if used incorrectly.[9]

Freilich et al.[10] outlined the general principles for selecting interocclusal records. They stated that for opposing casts to be held together in a stable and reproducible manner, both a tripod of vertical support and satisfactory horizontal stability between the two casts are required. Lassila[11] studied the effects of storage and concluded that elastomeric interocclusal recording materials remained dimensionally stable for a long time and moisture caused considerable expansion, warranting proper packaging during storage and transfer. Although no material satisfies all the requirements, a range of physical properties are desirable for ideal interocclusal recording materials. These are low viscosity, low resistance to closure, ease of use, adequate working time, precision in detail, rapid hardening, biocompatibility, and dimensional stability.[12] Dimensional changes have been attributed to the polymerization shrinkage during the setting process.[13,14] Various studies have demonstrated that the polymerization reaction is not the only factor that affects the shrinkage of silicone-based impression materials because evaporation of the constituents also contributes to the shrinkage. Hence, the aim of this study was to evaluate and compare accuracy and dimensional stability of five interocclusal recording materials post disinfection as a function of time. Tejo et al. conducted research to evaluate the time-dependent linear dimensional stability of three interocclusal recording materials and concluded that polyether bite registration materials showed less distortion with good dimensional stability compared to polyvinyl siloxane and zinc oxide eugenol at 1, 24, 48, and 72 hours.[15]

The materials evaluated and compared in the present study were Aluwax (Maarc), zinc oxide eugenol paste (DPI), polyether (Ramitec), polyvinyl siloxane (O Bite), and bisacrylic bite registration material (Luxabite). The result of this present study is in accordance with the finding of Gounder R, who compared and measured the accuracy of Aluwax, polyvinyl siloxane, and polyether interocclusal recording materials with disinfection using 0.5% chlorhexidine gluconate, 1% sodium hypochlorite, and 2% glutaraldehyde using immersion and spray atomization techniques for 30 and 60 minutes, which are being clinically acceptable.

Aluwax (wax) showed no dimensional changes when immersed in 5% sodium hypochlorite for 60 minutes. Contraction in the form of shrinkage occurs at 0.25% when immersed in sodium hypochlorite for 10 minutes. Aluwax has gained wide acceptance for interocclusal record transfer; however, studies showed that waxes contain aluminum or copper particles, which have a flow rate of 2.5–22% at 37.5 °C, so that they are susceptible to distortion upon removal from the mouth. Variation in the dimension may be attributed to the greater coefficient of thermal expansion and distortion due to stress release.[4]

The zinc oxide eugenol impression paste showed no dimensional changes when immersed for 60 minutes in both 2% glutaraldehyde and 5% sodium hypochlorite solutions. Expansion occurs at 0.69% when immersed in 2% glutaraldehyde and 0.24% when immersed in 5% sodium hypochlorite solutions both for 10 minutes. It allows almost no resistance to closing of the mandible, thus, allowing more accurate interocclusal relationship record to be formed. It is more stable than wax.[6]

In the above study, O-Bite (polyvinyl siloxane) showed expansion at 50, 2.13, 0.50, and 0.59% when immersed in 2% glutaraldehyde solution for 10 and 60 minutes and 5% sodium hypochlorite solutions for 10 and 60 minutes, respectively. It might be due to the addition of surfactants to improve its ability to reproduce details. The presence of these agents improves the compatibility with water and increases the sorption of water when impressions are immersed for longer period.[4]

Ramitec (polyether) interocclusal recording material showed expansion at 0.20, 1.83, 0.69, and 0.54 when immersed in 2% glutaraldehyde solution for 10 and 60 minutes and 5% sodium hypochlorite solutions for 10 and 60 minutes, respectively. This can be explained by the fact that polyether impression materials are hydrophilic, resulting in the absorption of moisture and expansion of the material.

Luxabite (bisacrylic) showed no dimensional changes when immersed in both 2% glutaraldehyde and 5% sodium hypochlorite solutions for 10 and 60 minutes.

Luxabite is a dimethacrylate-based interocclusal recording medium. It has shown accuracy and dimensional stability better than Ramitec interocclusal recording material. The mean percentage of dimensional changes is 0.20, 1.83, 0.69, and 0.54% when immersed in 2% glutaraldehyde solution for 10 and 60 minutes and 5% sodium hypochlorite solution for 10 and 60 minutes, respectively. No dimensional change was found with Luxabite after immersion in both the solutions. The expansion associated with Ramitec can be explained by the fact that polyether impression materials are hydrophilic, resulting in the absorption of moisture and expansion of the material. Aluwax being a cost effective material is widely accepted, with the addition of aluminium or copper particles which have a flow rate of 2.5–22% at 37.5 °C so that the susceptibility to distortion upon removal from the mouth is reduced.

In this study, bisacryl interocclusal recording material yielded the least error among the materials studied. They are easy to manipulate and do not need a carrier when used in the mouth. They offer little or no resistance to closure, set to a consistency that makes them easy to trim without distortion, and accurately reproduce tooth details post disinfection.

According to the results obtained in this study, it is recommended that after disinfection of Aluwax and ZOE into 5% NaOCl and 2% glutaraldehyde, the interocclusal material should be articulated within 60 minutes. Polyether interocclusal material should be articulated after 60 minutes of immersion into 5% NaOCl. Polyvinyl siloxane interocclusal material should be articulated after 10 minutes of immersion into both solutions. The interocclusal recording materials should be articulated to get a correct restoration to have a very minimum distortion and maximum satisfaction without failure of prosthesis.

A possible limitation of this study is that it takes only the linear measurement as a parameter for determining dimensional stability as in routine clinical situations, while dimensional errors occur in all three dimensions. The conditions during interocclusal record making differed from the natural oral environment.

Conclusions

Within the limitation of this study, the following conclusions can be drawn: Ramitec (polyether) showed minimum dimensional stability after immersion in 2% glutaraldehyde solution for 60 minutes. Zinc oxide eugenol showed the maximum dimensional stability when immersed in 2% glutaraldehyde and 5% sodium hypochlorite for 60 minutes. Aluwax showed the maximum dimensional stability when immersed in 5% sodium hypochlorite for 60 minutes. O-Bite (polyvinyl siloxane) shows the maximum dimensional stability when immersed in 2% glutaraldehyde and 5% sodium hypochlorite for 10 minutes. An increase in immersion time increases the changes of dimensional inaccuracy.

Clinical Significance

Prevention of cross-contamination between patients, dentists, auxiliary persons, and technicians when handling interocclusal recording media without hampering the treatment is the outcome to obtain a successful treatment.

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