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A COMPARATIVE EVALUATION OF COMPRESSION RESISTANCE OF COMMERCIALLY AVAILABLE INTEROCCLUSAL RECORDING MATERIALS: AN IN - VITRO STUDY

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ABSTRACT

Interocclusal recording materials are used to register jaw relationships for mounting dental casts on an articulator. The resistance of these materials to compressive forces is critical, because any deformation during the recording or mounting process would result in, inaccurate articulation of casts and faulty fabrication of restorations. Different commercially available interocclusal recording materials were used in the study viz Aluwax, jetbite, Ramitec and Aluwax plus zinc oxide eugenol combination. Twenty samples each were prepared on verticulator at 2mm, 4mm and 6mm thickness. The compressive resistance was measured on universal testing machine when a constant load of 25N was applied for 1 minute after 24 hours of fabrication of samples. Results showed statistically significant difference of compression resistance in all groups at various thickness as p value <0.001. Samples of 2mm thick of all tested materials showed least compression. Metalized wax showed maximum compression resistance of all tested interocclusal recording materials. It was concluded that all interocclusal recording materials were compressed at various thicknesses, but degree of compressibility is different.

KEYWORDS: Interocclusal recording material, compressive resistance, Metalized wax, Polyether, Polyvinylsiloxane, Zinc oxide eugenol.

INTRODUCTION

The fabrication of a well-fitting prosthesis requires that the articulator should simulate the patient's mandibular movements as closely as possible. The articulator requires interocclusal records for mounting casts and their programming. An interocclusal record is a precise recording of maxillo-mandibular position.[1] Any inaccuracy in interocclusal records leads to occlusal errors in the final prosthesis. The interocclusal record can be defined as a registration of positional relationship of the opposing teeth and arches.[2]

The final evaluation of any prosthesis depends upon whether the resultant maxillo-mandibular relationship is in harmony with the anatomy of the patient. This relationship is not a simple mandibular opening and closing but a complex 3-D relationship in the vertical antero-posterior, and medio-lateral position, along with dissimilarities on the two sides.[3]

There are various methods of recording maxillo-mandibular relationship namely, graphic, functional, cephalometric, and direct interocclusal records. Direct interocclusal records are used most commonly because of their simplicity. The prerequisites for interocclusal record materials are as follows.[4]

- The material should offer limited resistance before setting to avoid displacing the teeth or mandible during closure.
- After setting, it should be rigid or resilient, with minimal dimensional change.
- It should be easy to manipulate with no adverse effects on the tissues involved in the recording procedure.

- It should accurately record the incisal and occlusal surfaces of teeth.
- It should be verifiable.

The resistance to compression after setting is a very desirable property for any interocclusal recording material. Maxillo-mandibular relationship that is registered correctly in the patient can be erroneously transferred in the mounting procedure because of the compressibility of the set recording material. If a material is compressible, it can be distorted by faulty manipulation by the operator or by the weight of the casts to be mounted. The clinician should choose an interocclusal recording material that displays the least elastic or plastic distortion under compression after it is set.[5] A compressive force is commonly exerted on the interocclusal recording material during recording and articulation of casts and may cause inaccuracies during mounting of the casts and distortion during fabrication of the restorations.[6] The ability of an inter occlusal recording material to resist compressive forces is critical because of the potential for these inaccuracies. The deformation may vary with the thickness and the properties of the recording materials used.[7]

Silverman[3] stated that an accurate centric relation record can be obtained only with minimal closing pressure. Any attempt to make a record with anything more than minimal closing pressure generally leads to an incorrect centric relation.

The report of the Principles, Concepts, and Practices Committee of the Academy of Denture Prosthetics states that, "A centric jaw relation record that is used for relating the mandibular cast on the articulator should represent an unstrained maxillary and mandibular ridge relation'.

Various materials are used for registration of the occlusal relationship between natural and/or artificial teeth for planning occlusal rehabilitation and fabrication of a prosthesis. Dental plaster, impression compound, waxes, metalized wax, zinc oxide-eugenol paste, alginate impression material, acrylic resin, elastomers, pressure sensitive films, typewriter ribbon, transeparent acetate sheet, occlusal sonography and T-scan materials are products routinely used for the registration of the occlusal relationship.[8,9]

The aim and objective of the present study is to evaluate and compare the compressive resistance at various thicknesses of different interocclusal recording materials when subjected to a constant compressive load.

MATERIALS AND METHOD

Four different types of interocclusal recording materials and a combination of materials were used in the study namely, metalized wax (Aluwax, Aluwax dental product co. Michigan, USA) metalized wax plus zinc oxide eugenol impression paste (DPI impression paste, dental products of India, Mumbai), polyvinlysiloxane (Jet bite, Coltene Whaledent AG, Switzerland) and polyether bite registration paste(Ramitec, 3M ESPE, Bangalore, India). Pair of dentulous casts was used for the study. Samples were prepared on indigenously made calibrated verticulator. Two dentulous casts maxillary and mandibular were obtained from moulds. These casts were manually articulated at maximum intercuspation position and maintained in this position by sticky wax. The casts were articulated on verticulator. Experimental samples of 2mm, 4mm and 6mm thickness of the recording materials were made on verticulator. Total 240 samples were prepared for the study and they were divided into four groups. All the groups were further subdivided into three subgroups according to three thicknesses-

Group 1: Metalized wax bite registration material
1A: samples of 2mm thickness
1B: Samples of 4mm thickness
1C Samples of 6mm thickness

Group 2: Metalized wax relined with zinc oxide eugenol (ZOE) bite registration material
2A: samples of 2mm thickness
2B: Samples of 4mm thickness
2C Samples of 6mm thickness

Group 3: Jet bite polyvinlysiloxane bite registration material
3A: samples of 2mm thickness
3B: Samples of 4mm thickness
3C Samples of 6mm thickness

Group 4: Ramitec polyether bite registration material
4A: samples of 2mm thickness
4B: Samples of 4mm thickness
4C Samples of 6mm thickness

Registration of different recording materials on verticulator

Registration with metalized wax

Registrations were obtained with Aluwax of 2mm, 4mm, and 6mm thickness. The wax was softened at 108^0F in a temperature controlled water bath and placed on the articulated occlusal surface of mandibular cast and verticulator was closed to obtain occlusal registrations of 2mm, 4mm and 6mm thickness. Registration was removed after the wax had cooled. It was immediately dipped in chilled water to harden and stored in tightly sealed thermal insulated containers until analysis for 24 hrs.

Registration with metalized wax relined with ZOE paste

Metalized wax sheet of 1.5 mm thickness was made and checked on verticulator for an adequate space for the zinc oxide eugenol impression paste. A thin layer of cold mould seal was applied on the occlusal surfaces of the mounted casts to facilitate easy removal of the set recording material. A thin layer of zinc oxide eugenol

impression paste was coated on both the upper and lower surface of metalized wax sheet and the specimen was placed on the verticulator to close. Record was removed after 8 min. By this method 20 samples each were made of 2mm, 4mm and 6mm thickness. All the samples were stored in tightly sealed thermal insulated containers until analyzed.

Registrations with Polyvinylsiloxane bite registration paste

The cartridge was placed in the dispensing gun with the mixing tip attached to it and was injected on the mounted mandibular occlusal surface of cast, close the verticulator and allowed the material to set. Record was removed after 6 minutes. By this method 20 samples each were made of 2mm, 4mm and 6mm thickness. Samples was removed after setting and stored in tightly sealed thermal insulated containers until analyzed.

Registration with polyether bite registration paste

On the verticulator casts were adjusted such that 2 mm space existed between the maxillary and mandibular casts. Proper ratio of base paste and catalyst paste was taken according to manufactured directions and squeezed onto a mixing pad, the catalyst paste is first collected on a stainless steel spatula and then distributed over the base and mixture is spread out over a mixing pad. The process is continued until the mixed mass is of uniform color with no streaks. The mixed mass was loaded into a syringe and was injected over the occlusal surfaces of mandibular cast. Verticulator was closed in proper position and material was allowed to set. Samples was removed after setting and stored till analysis. In this manner, twenty samples each of 2mm, 4mm and 6mm were prepared.

Evaluation of compressive resistance

The stored samples were repositioned on the dentulous casts and casts were placed in the Instran universal testing machine. The casts were subjected to a constant compressive force of 25 N for duration of 1 minute. The compressive displacement for each group of material at 2mm, 4mm and 6mm thickness was tabulated and statistically analyzed.

RESULTS

All the data recorded and analyzed with the help of the statistical package for social scientist (SPSS) computer software version 20. Table 1 showed the mean displacement values of different test materials at 2mm thickness, where metalized wax showed least displacement0.047 mm followed by polyvinylsiloxane 0.066 mm, metalized wax plus ZOE 0.155 mm and maximum in polyether 0.161mm.

Analysis of variance in table 2 showed highly statistically significant difference at 2mm, p value $p<0.001$. Intergroup comparison of 2mm thickness showed significant difference between groups except metalized wax vs polyvinylsiloxane and metalized wax plus ZOE vs polyether groups (table 3).

Table 1: Displacement in mm with 2mm thickness.

S no.	Group	No of samples	Mean	SD	Min	Max
1	Metalized wax	20	0.047	0.014	0.035	0.072
2	Metalized wax + ZOE	20	0.158	0.010	0.140	0.170
3	Polyvinylsiloxane	20	0.066	0.009	0.049	0.075
4	Polyether	20	0.161	0.005	0.154	0.168

Table 2: Analysis of variance (ANOVA).

	Sum of squares	Df	Mean square	F	Significance
Between groups	0.217	3	0.072	690.368	<0.001
Within groups	0.008	76	0.0001		
Total	0.225	79			

Table 3: Intergroup comparison of displacement in 2mm.

S no	Comparison	t	p
1	Metalized wax vs Metalized wax+ZOE	-28.385	<0.001
2	Metalized wax vs polyvinylsiloxane	-4.978	>0.05
3	Metalized wax vs polyether	-33.733	<0.001
4	Metalized wax+ZOE vs polyvinylsiloxane	29.985	<0.001
5	Metalized wax+ZOE vs polyether	-1.079	>0.05
6	Polyether vs polyvinylsiloxane	-40.329	<0.001

Table 4 showed the displacement values of different test materials of 4mm thickness, where metalized wax showed least displacement 0.175 mm followed by polyvinylsiloxane 0.176 mm, metalized wax plus ZOE 0.214 mm and maximum in polyether 0.461mm.

Analysis of variance in table 5 showed highly statistically significant difference of 4mm thickness samples, p value $p<0.001$. Intergroup comparison of 4mm thickness showed significant difference between

groups except metalized wax and polyvinylsiloxane groups (table 6).

Table 4: Displacement in mm with 4mm thickness.

S no.	Group	No of samples	Mean	SD	Min	Max
1	Metalized wax	20	0.175	0.010	0.160	0.190
2	Metalized wax + ZOE	20	0.214	0.005	0.206	0.220
3	Polyvinylsilicone	20	0.176	0.019	0.152	0.196
4	Polyether	20	0.461	0.016	0.440	0.480

Table 5: Analysis of variance (ANOVA).

	Sum of squares	Df	Mean square	F	Significance
Between groups	1.139	3	0.380	2063.134	<0.001
Within groups	0.014	76	0.0002		
Total	1.153	79			

Table 6: Intergroup comparison of displacement in 4mm

S no	Comparison	t	p
1	Metalized wax vs Metalized wax+ZOE	-14.975	<0.001
2	Metalized wax vs polyvinylsiloxane	-0.124	>0.05
3	Metalized wax vs polyether	-68.699	<0.001
4	Metalized wax+ZOE vs polyvinylsiloxane	-8.620	<0.001
5	Metalized wax+ZOE vs polyether	-67.454	<0.001
6	Polyether vs polyvinylsiloxane	-52.016	<0.001

Table 7 showed the displacement values of different test materials of 6 mm thickness, where metalized wax showed least mean displacement 0.241 mm followed by polyvinylsiloxane 0.246 mm, metalized wax plus ZOE 0.386 mm and maximum in polyether 0.572 mm. Analysis of variance in table 8 showed very high statistically significant difference of 6 mm thickness samples, p value p<0.001. Intergroup comparison of 6 mm thickness showed significant difference between groups except metalized wax and polyvinylsiloxane groups (table 9).

Table 7: Displacement in mm with 6mm thickness.

S no.	Group	No of samples	Mean	SD	Min	Max
1	Metalized wax	20	0.241	0.003	0.238	0.245
2	Metalized wax + ZOE	20	0.386	0.017	0.360	0.410
3	Polyvinylsiloxane	20	0.246	0.019	0.210	0.260
4	Polyether	20	0.572	0.024	0.540	0.610

Table 8: Analysis of variance (ANOVA).

	Sum of squares	Df	Mean square	F	Significance
Between groups	1.454	3	0.485	1606.1331	<0.001
Within groups	0.023	76	0.0003		
Total	1.476	79			

Table 9: Intergroup comparison of displacement in 6mm.

S no	Comparison	t	p
1	Metalized wax vs Metalized wax+ZOE	-38.119	<0.001
2	Metalized wax vs polyvinylsiloxane	-1.171	>0.05
3	Metalized wax vs polyether	-61.700	<0.001
4	Metalized wax+ZOE vs polyvinylsiloxane	-24.874	<0.001
5	Metalized wax+ZOE vs polyether	-28.665	<0.001
6	Polyether vs polyvinylsiloxxane	-48.087	<0.001

The mean displacement of 4 mm and 6 mm thickness samples was significantly higher as compared with 2mm thick samples. However, 6 mm thick samples showed maximum displacement in all the tested groups (table 10,11,12,13).

Table 10: Intergroup comparison of displacement in metalized wax at different thickness.

S no.	Comparision	t	p
1	2mm vs 4mm	-24.629	<0.001
2	2mm vs 6mm	-75.847	<0.001
3	4mm vs 6mm	-23.707	<0.001

Table 11: Intergroup comparison of displacement in metalized wax plus ZOE at different thickness.

S no.	Comparision	t	p
1	2mm vs 4mm	-26.228	<0.001
2	2mm vs 6mm	-55.965	<0.001
3	4mm vs 6mm	-43.283	<0.001

Table12: Intergroup comparison of displacement in polyvinylsiloxane at different thickness.

S no.	Comparision	t	p
1	2mm vs 4mm	-19.595	<0.001
2	2mm vs 6mm	-32.312	<0.001
3	4mm vs 6mm	-15.375	<0.001

Table 13: Intergroup comparison of displacement in polyether at different thickness.

S no.	Comparision	t	p
1	2mm vs 4mm	-86.755	<0.001
2	2mm vs 6mm	-69.947	<0.001
3	4mm vs 6mm	-18.595	<0.001

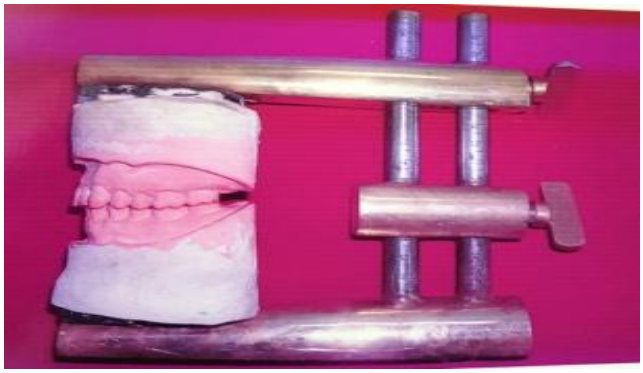

Fig: 1. Mounted cast.

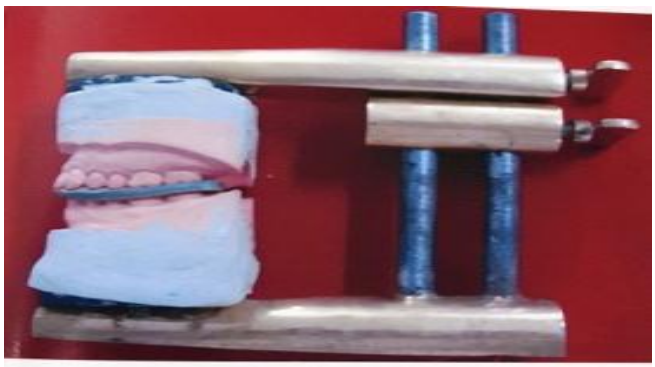

Fig: 2. Metalized registration.

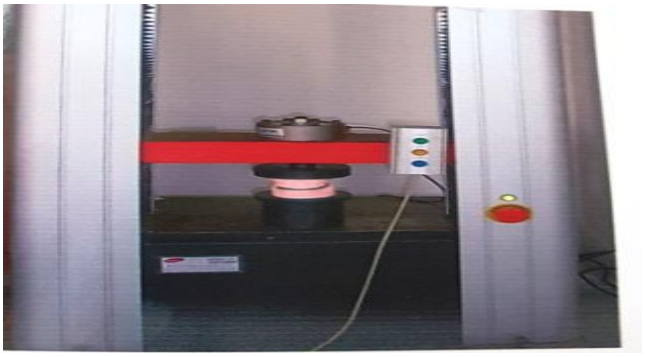

Fig: 3. Testing of samples.

DISCUSSION

In all cases of prosthetic rehabilitation diagnosis, proper planning and correct execution of clinical and laboratory procedures are mandatory for successful treatment and is highly dependent on precise mounting of the casts on the articulator. Thus, interocclusal records play an extremely important role in the diagnosis and final result. The first interocclusal registration was made in 1756 by Philip Pfaff. The resistance to compression after setting is a most desirable property for interocclusal recording media.[4]

The interocclusal relationship of mounted dental cast should be an accurate representation of the opposing dental arches. The clinicians should choose an interocclusal registration material that is dimensionally stable under compressive load. Although no single material satisfies the entire requirement, a range of physical properties are desirable for a recording material to be clinically acceptable. Of the various properties enumerated, compressive resistance is not apparent from the information provided by the manufacture.[7] It has been observed that distortion during mounting using interocclusal records occurred more frequently in the vertical direction.[10] The material should be rigid enough to resist the distortion that might be caused from the weight of the dental casts, the components of the articulator, or other means used to stabilize the cast during the mounting procedure. In the present study compressive resistance of four interocclusal recording materials viz metalized wax, metalized wax plus ZOE, polyvinylsiloxane and polyether were chosen for the study because they were commonly used materials for bite registrations. In the present study the samples were fabricated on indigenously made calibrated verticulator to simulate intra oral clinical situations. In previous studies[11,12,13] samples were made according to ADA specification number 19, that are not resembled clinically. For standardization the specimens were stored at room temperature for 24 hours to simulate the time between clinical and laboratory phase.

The interocclusal recording of different thickness, namely 2mm, 4mm and 6mm of the recording materials were selected in this study to simulate various clinical situations. The thin specimens would match the limited space between prepared teeth on one arch opposing

unprepared teeth and the larger thickness of material matches that between opposing edentulous arches.

In the present study, all the samples were subjected to a constant compressive load of 25N in a universal testing machine. Rubber bands are commonly used to sustain the contact of opposite cast during mounting procedures. The maximal force exerted by the use of one standard office supply rubber band no 19 to position casts mounted on an articulator was approximately 25 N.[6]

In the present study the mean displacement observed for the four groups, in increasing order was, metalized wax, polyvinylsiloxane, metalized wax plus Zinc oxide-Eugenol paste and Polyether, respectively. In other words, metalized wax showed the highest compressive resistance under the specific load and Polyether showed the least. Results of the present study support the findings of Filiz and Altunsoy[14] who stated that recording wax exhibited the greatest resistance to compression than silicone and polyvinylsiloxane elastomeric material. Dua P et al[7] also observed that the compressive resistance was minimum for polyether among all the elastomeric interocclusal recording materials. Lasilla and McCabe[15] their study concluded that the tendency for the interocclusal registration to deform was more common with elastomeric materials as compared to Zinc oxide-Eugenol registration paste. Though metalized wax showed maximum resistance to compression in this study but studies showed that metalized wax bite registration material exhibit poor dimensional stability[4,8] but in a study of Sandeep et al[16] demonstrated that metalized wax (Aluwax) exhibits good dimensional stability on 1st day, so can be used if the mounting procedures to be carried out immediately.

Study of Michalakis et al[5] showeded that Polyether and other elastomeric interocclusal recording materials exhibited better resistance to compression as compared to metalized wax and Zinc oxide-Eugenol registration paste. The difference in observation may be attributed to the difference in methodology. They fabricated cylinders of the registration material of much greater thickness instead of taking registration records. Craig and Sun[7] observed that several bite registration elastomers had a desirable combination of high stiffness and low permanent deformation at the time of removal.

Polyvinylsiloxane bite registration materials are characterized by short working time, setting time, high stiffness, low permanent strain in compression, and low flow.[17] In this study, Polyvinylsiloxane bite registration material showed greater resistance to compression than Polyeter bite registration material. The reason for the greater compression resistance of polyvinylsiloxane bite registration material may be because of its low dimensional change compared to Polyether bite registration material. Studies done by Craig RG and Sun Z, Chai J, Tan E and Pang I C, Campos A A and Nathanson D[7,17,18,19] have also shown that polyvinylsiloxane bite registration material was more accurate and dimensionally stable than Polyether bite registration material.

Metalize wax relined with zinc oxide eugenol paste showed a decrease in compressive resistance when compared to other interocclusal recording materials. The reason for the decreased compressive resistance may be their long setting time, significant brittleness, and loss of vital portions of the record through breakage.[4]

From the present study, it was evident that samples of 2mm thickness had the highest compressive resistance and the compressive resistance decreased as the thickness of interocclusal records increased for all the four groups under observation. Certain studies with similar parameters have been conducted earlier that support the observations as records in the present study. Dua P et al[7] demonstrated that the compressive resistance is inversely proportional to the thickness of the sample. This implies that minimum thickness of the recording material should be used for recording maxilla-mandibular relations without sacrificing the strength for the interocclusal record. Larry and Donna,[6] Filiz and Altunsoy[14] observed that varying thickness (2mm, 5mm, 10mm, and 20mm) of interocclusal record material provided varying degree of compressive resistance and concluded that interocclusal record with minimal thickness provide maximum compressive resistance.

There are some limitations of the study also. There was no simulation of intra oral mouth temperature during the setting of the materials in this study. Further study is also needed to evaluate how much time after the maxilla-mandibular registration procedure the articulation of the cast should take place, also taking into account the dimensional stability of the materials.

CONCLUSION

The following conclusions can be drawn-

1. All interocclusal recording materials in this study were compressed.
2. The compression resistance was found to decrease with increase in thickness for all the interocclusal recording materials.
3. Metalized wax bite registration material showed the greatest resistance to compression.
4. The order of resistance to compression of interocclusal bite registration materials in this study is as follows:

Metalized wax > Polyvinylsiloxanme > metalized wax plus ZOE > Polyether

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