Original Article

Comparative Evaluation of the Compression Resistance of Different Interocclusal Recording Materials: An *In Vitro* Study

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Abstract

Purpose: The purpose of the study is to compare the compression resistance of different interocclusal recording materials. **Background:** Jaw relation records are a fundamental and crucial component of providing accurate, high-quality fixed restorations. Jaw relations are classified as orientation, vertical and horizontal relations. Orientation relations establish the references in the cranium. Vertical relations establish the amount of jaw separation allowable of dentures. Horizontal relations establish the front to back and side to side relationships of one jaw to the other both as extreme border line movement and functional movement. **Materials and Methods:** Four types of interocclusal recording media were used in the study. Three were addition silicones (Imprint Bite-Group A, Virtual Refill-Group B, Jet Bite-Group C), and one a polyether material (Impregnum-Group D). A total of 80 samples were fabricated. The 20 samples of each group were further subdivided into four subgroups of five samples each. Each of the test samples was loaded on a universal testing machine and subjected to a constant compressive force of 25 Newton for a duration of 1 min. **Statistical Analysis:** Statistical Package for the Social Sciences version 21.0. **Results:** The results were subjected to a statistical analysis using a one-way analysis of variance for compression distances between interocclusal recording materials. **Conclusion:** It was concluded that Virtual Refill polyvinylsiloxane bite registration material showed greater resistance to compression than the other interocclusal recording materials in the 2, 5, 10, and 20 mm thickness groups.

Keywords: Interooclusal, Recording materials, Working casts.

Introduction

In prosthodontics, diagnosis and treatment planning are the key determinants for a successful treatment outcome. It is important to attain a balance between the maxillomandibular relationship of a patient. Accurate diagnostic casts properly mounted on an articulator with correctly established interocclusal records is of prime importance in the fabrication of fixed partial dentures and it can lead to restorations that require minimal occlusal modifications intraorally, thus reducing the chairside time.[1] The maxillomandibular relation on an articulator is governed by the properties of the material used to record a specific intraoral position of the mandible to the maxillae. For an ideal interocclusal registration material, requirements include limited initial resistance to closure, dimensional stability after setting, resistance to compression after polymerization, ease of manipulation.[2,3] A compressive force is commonly exerted on the interocclusal recording material during the articulation procedure which may cause inaccuracy during mounting of cast and distortion during fabrication of the restoration.[4] There is disagreement in the literature regarding the superiority between polysulfide rubbers, condensation silicones, and polyether. And the polyvinylsiloxanes have recently claimed even superior accuracy and stability over polyethers. The purpose of this study was to make a comparative evaluation of the compression resistance of representative products.

Materials and Methods

Four types of interocclusal recording media were used in the study. Three were addition silicones (Imprint bite, Virtual Refill, Jet Bite), and one a polyether material (Impregnum). A master

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cylindrical die in the form of hollow cylinders which was opened at both ends was machine tooled for the purpose of this study (Figures 1 and 2). Four metal cylinders of 10 mm internal diameter and four different lengths of 2 mm, 5 mm, 10 mm, and 20 mm depending upon the height of 20 test samples for each of the four materials were fabricated with 5 samples of 2 mm, 5 mm, 10 mm, and 20 mm thickness each (Figures 3-6). Thus a total of 80 samples were fabricated. These groups were designated as: Group A (Imprint bite), Group B (Virtual Refill), Group C (Jet Bite), and Group D (Impregnum). The 20 samples of each group were further subdivided into four subgroups of five samples each. These subgroups were designated as Subgroup I of 2 mm thickness, Subgroup II of 5 mm thickness and Subgroup III of 10 mm thickness, and Subgroup IV of 20 mm.

The samples were stored in tightly-sealed containers and kept for 24 h before testing. compressive resistance was tested using a universal measuring machine (Figure 7). Each of the test samples was loaded on a universal testing machine (Figure 8) and subjected to a constant compressive force of 25 Newton for a duration of 1 min. The compression resistance distance was tabulated and analyzed using one-way analysis of variance (ANOVA) test and Tukey HSD by using Statistical Package for the Social Sciences software. The results were subjected to a statistical analysis using one-way ANOVA for compression distances between interocclusal recording materials.

Figure 1: Metallic hollow cylinders

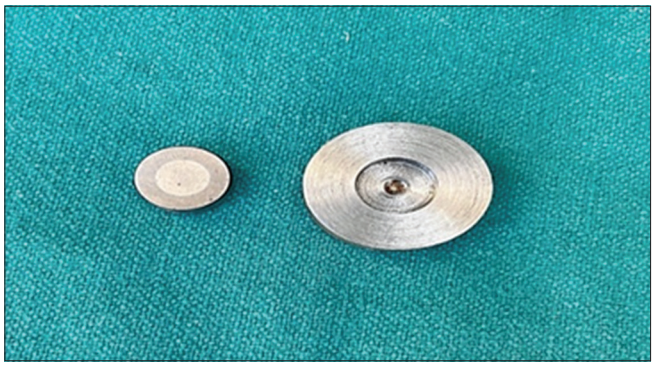

Figure 2: Metallic hollow cylinders

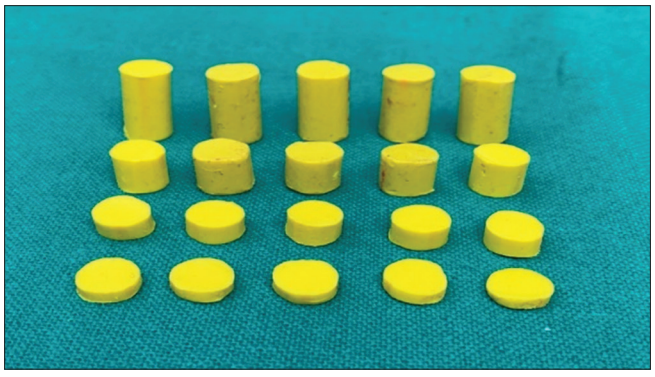

Figure 3: Imprint bite samples

Results

The results of the study pertaining to the compressive resistance of the four selected interocclusal bite registration materials and

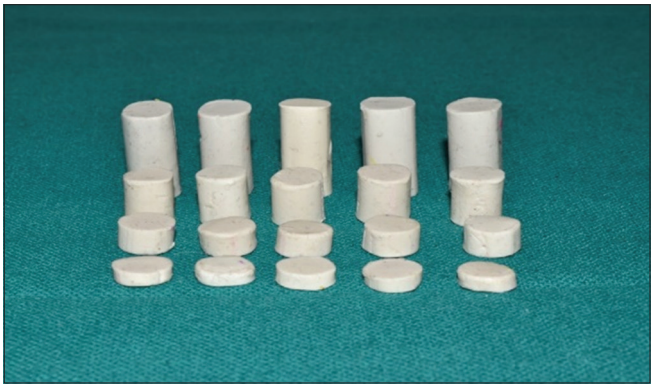

Figure 4: Virtual refill samples

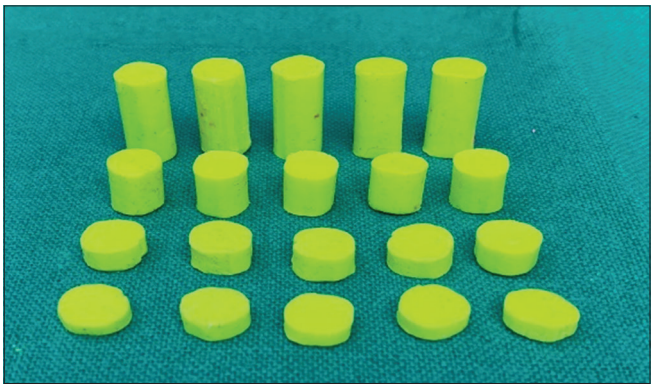

Figure 5: Jet bite samples

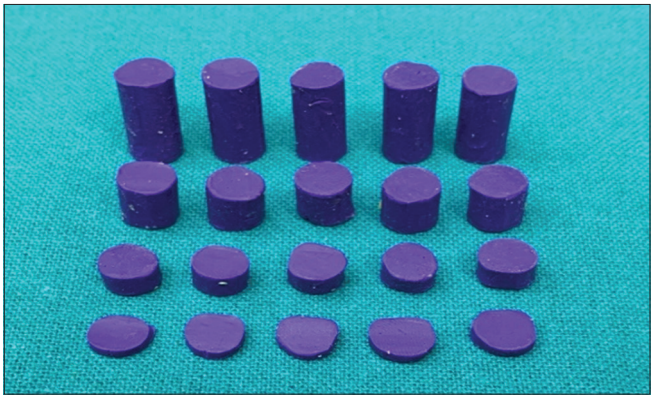

Figure 6: Impregnum samples

the statistical evaluation are given in Tables 1-4. Descriptive data included mean, standard deviation, coefficient of variation, and range values of the groups. Comparisons between the groups and within the groups were done and $P < 0.05$ was considered as statistically significant. The compression resistance of the four interocclusal bite recording materials was recorded. The findings of the study described that the 2 mm thickness specimens showed the least compression and 20 mm thickness specimen showed maximum compression under a constant load of 25 N as tabulated from Tables 1-4 for all the four materials tested. This observation concluded that as the thickness increases, compression resistance also increases.

Figure 7: Universal testing machine

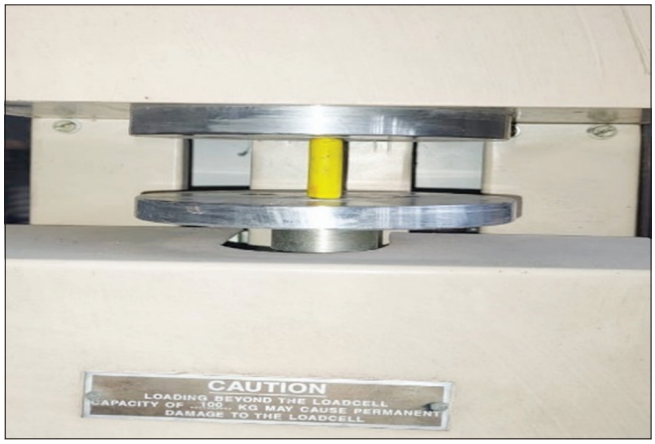

Figure 8: Samples being tested on UTM

Discussion

During restorative phase of any dental treatment, the precise articulation of patient's diagnostic or working casts is imperative for contriving of clinically acceptable prosthesis. Interocclusal recording materials are generally used to record the maxillomandibular relationships. Impressions must be steady enough to produce error free casts over extended periods of time. This necessitate a more stable, accurate, and elastic impression material sponsored the introduction of elastomers into dentistry.

A compressive force exerted on the recording material during the articulation procedure which may cause imperfections during mounting of casts. Different interocclusal recording materials exhibit a degree of malformation when compressed under a specific load. This contortion may vary with the thickness and the properties of the recording materials used.[5] Four fundamental types of elastomer impression materials are currently in use in the dental profession: (1) Silicone rubbers which polymerize by a condensation reaction, (2) Polysulfide (mercaptan) rubbers, (3) Polyethers, and (4) Silicones which co-polymerize an addition reaction. The latter has been introduced relatively recently and are also called polyvinylsiloxanes.[6] This study was undertaken to evaluate and compare Compression Resistance of different interocclusal recording materials under constant load and to evaluate the manipulation of the different interocclusal recording materials. Rubber bands are commonly used to sustain the contact of opposing casts during mounting procedures. The maximal force exerted by the use of one office standard rubber band

Table 1: Between group comparison of compression distance values - 2 mm

		Imprint bite	Virtual refill	Jet bite	Impregnum	F-value	*P*-value (ANOVA test)
Mean		0.806	0.042	0.184	0.104	5913.93	0.0001*
SD		0.02	0.002	0.001	0.004		
Post-hoc analysis (Tukey's HSD *post-hoc* test)							
Group (I)	Group (J)	95% of confidence interval		Difference	*P*-value		
		Lower	Upper				
Imprint bite	Virtual refill	–0.7826	–0.7454	–0.764	0.0001*		
	Jet bite	–0.6406	–0.6034	–0.622	0.0001*		
	Impregnum	–0.7206	–0.6834	–0.702	0.0001*		
Virtual refill	Jet bite	0.1234	0.1606	0.142	0.0001*		
	Impregnum	0.0434	0.0806	0.062	0.0001*		
Jet bite	Impregnum	–0.0986	–0.0614	0.080	0.0001*		

*$P<0.05$ is statistically significant (ANOVA test and Tukey's HSD *post-hoc* test), Regarding between group comparison, ANOVA test shows statistically significant difference between materials at 2 mm thickness ($P<0.05$). *Post-hoc* test shows all the pair group comparisons were also statistically significant ($P<0.05$), ANOVA: Analysis of variance

Table 2: Between group comparison of compression distance values- 5 mm

	Imprint bite	Virtual refill	Jet bite	Impregnum	F-value	*P*-value (ANOVA)
Mean	0.138	0.104	0.385	0.153	10976.23	0.0001*
SD	0.002	0.001	0.003	0.004		

Post-hoc analysis (Tukey's HSD *post-hoc* test)

Group (I)	Group (J)	95% of confidence interval		Difference	*P*-value
		Lower	Upper		
Imprint bite	Virtual Refill	–0.0390	–0.0290	–0.034	0.0001*
	Jet bite	0.2420	0.2520	0.247	0.0001*
	Impregnum	0.0100	0.0200	0.015	0.0001*
Virtual Refill	Jet bite	0.2760	0.2860	0.281	0.0001*
	Impregnum	0.0440	0.0540	0.049	0.0001*
Jet bite	Impregnum	–0.2370	–0.2270	0.232	0.0001*

*P<0.05 is statistically significant (ANOVA test and Tukey's HSD *post-hoc* test), Regarding between group comparison, ANOVA test shows statistically significant difference between materials at 5 mm thickness (P<0.05). *Post-hoc* test shows all the pair group comparisons were also statistically significant (P<0.05). ANOVA: Analysis of variance

Table 3: Between Group Comparison of compression distance values - 10mm

	Imprint bite	Virtual refill	Jet bite	Impregnum	F-value	*P*-value (ANOVA test)
Mean	0.236	0.184	0.512	0.283	14935.6	0.0001*
SD	0.003	0.003	0.001	0.003		

Post-hoc analysis (Tukey's HSD *post-hoc* test)

Group (I)	Group (J)	95% of confidence interval		Difference	*P*-value
		Lower	Upper		
Imprint bite	Virtual Refill	–0.0568	–0.0472	–0.05	0.0001*
	Jet bite	0.2712	0.2808	0.276	0.0001*
	Impregnum	0.0422	0.0518	0.047	0.0001*
Virtual Refill	Jet bite	0.3232	0.3328	0.328	0.0001*
	Impregnum	0.0942	0.1038	0.099	0.0001*
Jet bite	Impregnum	–0.2338	–0.2242	0.229	0.0001*

*P<0.05 is statistically significant (ANOVA test and Tukey's HSD *post-hoc* test), Regarding between group comparison, ANOVA test shows statistically significant difference between materials at 10 mm thickness (P<0.05). *Post-hoc* test shows all the pair group comparisons were also statistically significant (P<0.05). ANOVA: Analysis of variance

Table 4: Between group comparison of compression distance values – 20 mm

	Imprint bite	Virtual refill	Jet bite	Impregnum	F value	*P*-value (ANOVA test)
Mean	0.441	0.410	0.946	0.579	2978.555	0.0001*
SD	0.002	0.022	0.001	0.001		

Post-hoc analysis (tukey's hsd *post-hoc* test)

Group (I)	Group (J)	95% of confidence interval		Difference	*P*-value
		Lower	Upper		
Imprint bite	Virtual Refill	–0.0492	–0.0128	–0.031	0.0001*
	Jet bite	0.4868	0.5232	0.505	0.0001*
	Impregnum	0.1198	0.1562	0.138	0.0001*
Virtual Refill	Jet bite	0.5178	0.5542	0.536	0.0001*
	Impregnum	0.1508	0.1872	0.169	0.0001*
Jet bite	Impregnum	–0.3852	–0.3488	–0.367	0.0001*

*P<0.05 is statistically significant (ANOVA test and Tukey's HSD *post-hoc* test), Regarding between group comparison, ANOVA test shows statistically significant difference between materials at 20 mm thickness (P<0.05). Post hoc test shows all the pair group comparisons were also statistically significant (P<0.05). ANOVA: Analysis of variance

(No. 19) to a position a maxillary cast to a mandibular cast mounted on an articulator was approximately 25 N. Total 80 samples were made i.e. the 20 samples of each group were subdivided into four subgroups of five each. These subgroups were designated as Subgroup A (2 mm length), Subgroup B (5 mm length), Subgroup C (10 mm length), and Subgroup D (20 mm length). The samples were stored in tightly sealed containers and kept for 24 h before testing. The compressive resistance was tested using a universal testing machine and quantifications were done using traveling micrometer microscope in millimeters. When compression resistance was evaluated in this study, it was observed that none of the samples obtained from different interocculusal recording materials were exactly similar in the dimensions at various thickness under a constant compressive load. The results of our study showed that Virtual Refill polyvinylsiloxane bite registration material showed greater defiance to compression than the other interocclusal recording materials in the 2, 5, 10, and 20 mm thickness groups.

A study conducted by Nagrath *et al*.,[7] which concluded that Virtual Refill polyvinylsiloxane bite registration material showed greater resistance to compression than Ramitec, Imprint Bite, and Jet Bite registration material when compressed under a constant force of 25N. This concurred with the result of the present study. The deformation may vary with thickness and the stiffness of the recording material. The material should be minimally thick, and an optimal material should exhibit minimal distortion during compression.[5] Similar results were shown in a study conducted by Breeding and Dixon,[8] showed that Polyvinylsiloxane displayed the greatest resistance to compression as compared to other elastomeric interocclusal recoding materials.

There were possible limitations to this study. It took only compression resistance as a parameter for determining the accuracy of final prosthetic restoration. There was no simulation of intra-oral mouth temperature during setting of the materials in this study. It also did not take into account the effect of storage on the material properties as some interocclusal record materials need to be stored in dry sealed containers. More parameters like dimensional stability, accurate surface reproduction could have been studied. So further studies can be done taking into consideration all these factors.

Conclusion

From the present study, the following conclusions have been drawn:

1. All recording materials in this study were compressed to significant distances during a constant compressive load
2. Significant differences in the compression existed between the interocclusal recording materials at each thickness tested
3. Compression resistance was found to decrease with increase in thickness for all the interocclusal recording materials
4. At 2 mm, 5 mm, 10 mm and 20 mm thickness the compression distance values obtained as follows

Imprint bite > Jet bite > Impregnum > Virtual Refill.

Limitations and Future Directions

The conclusions drawn are only preliminary and are based on a trial having a low statistical power which is often considered to be having a high risk for bias. Therefore, studies which involve a larger sample size should be designed to verify the predictability of presented results.

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