J Indian Prosthodont Soc (December 2014) 14(Suppl. 1):S76–S85
DOI 10.1007/s13191-014-0369-8

ORIGINAL ARTICLE

A Comparative Study to Evaluate the Compression Resistance of Different Interocclusal Recording Materials: An In Vitro Study

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Received: 8 November 2013 / Accepted: 10 May 2014 / Published online: 17 July 2014

Abstract Recording and transferring of accurate existing occlusal records is of prime importance for a successful restoration. An ideal occlusal registration material should provide minimal resistance to mandibular closure during the registration of maxillomandibular relationships. Interocclusal bite registration materials are partly responsible for accurate precision and occlusal quality of final prosthetic restorations when used for mounting casts on the articulators. The aim of selecting this study is to compare different types of recent interocclusal recording materials and to find the best among them which can resist a constant compressive load and will give the least inaccuracies. In the present study compressive resistance of four interocclusal recording materials viz. Imprint bite, Vitual refill, Jet bite and Ramitec at various thickness (2, 5, 10 and 20 mm) when subjected to a constant compressive load of 25 N was studied. The thickness of the interocclusal recoding materials were selected to simulate various clinical situations. For standardization, the specimens were stored at room temperature for 24 h to simulate the time between clinical and laboratory phases, $N = 20$ specimens from each group was selected (making a total sample size of $N = 80$). The SPSS version 17 has been used, two way ANOVA was applied to compare different types of recent interocclusal recording materials, p value ≤ 0.05 was considered statistically significant. A total of 80 samples were fabricated. Results of two-way analysis of variance ($p \leq 0.05$) indicated that there was a significant difference in compressive resistance among the materials of each thickness. The 2 mm thickness specimens showed the least compression and 20 mm thickness specimen showed maximum compression under a constant load of 25 N for all the four materials tested. Virtual Refill bite registration material showed the least compression value than Imprint bite polyvinylsiloxane registration material, Ramitec polyether bite registration material and Jet bite polyvinylsiloxane registration material with negligible error of 0.04 mm found in 2 mm thickness. The results of foregoing study showed that Virtual refill having greater resistance to compression than other interocclusal recording material at various thickness. It exhibit minimal distortion during compression and give clinician the opportunity to make only minimal adjustments to the restorations that were delivered from the laboratory and avoid unnecessary use of chairtime, or repetition of some clinical and technical stages

Keywords Interocclusal recording material · Compressive resistance · Bite registration

Introduction

For making a successful prosthesis, it is important to achieve a harmony between the maxillomandibular relationship and functional anatomy of the patient. Precise articulation of the patient's cast is a prerequisite for the purpose of diagnosis and subsequent corrective treatment.

Interocclusal bite registration materials are partly responsible for accurate precision and occlusal quality of final prosthetic restorations when used for mounting casts on the articulators. Accurate mountings can lead to restorations that require minimal occlusal modifications intraorally, thus reducing the chairside time [1]. Apart from the operator's clinical ability and the technique followed,

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Fig. 1 Imprint Bite PVS interocclusal recording material

Fig. 2 Vitual refill reflective PVS interocclusal recording material

the material used can critically affect the accuracy of interocclusal registration.

Diagnosis and treatment planning procedures may be inadequate if casts are fixed in inaccurate position. To prevent clinical error, the procedure used to record and transfer interocclusal relations should be performed with the utmost care and understanding [2].

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 [3]. The ability of an interocclusal recording material to resist compressive force is critical because of the potential for the inaccuracies. The deformation may vary with the thickness and the properties of the recording materials used [4].

Recording and transferring of accurate existing occlusal records is of prime importance for a successful restoration. Interocclusal recording of the relationship of the mandible to the maxilla is a simple but complex procedure. The inaccuracies attributed to the interocclusal records can be divided into three main categories: (1) The biologic characteristics of stomatognathic system, (2) Manipulation of the material and (3) The properties of the interocclusal recording materials [5].

There are various interocclusal recording materials viz. dental plaster with modifiers, modelling compound, waxes, acrylic resin and zinc oxide eugenol paste which exhibit a degree of deformation when compressed under a load. Recently, addition silicone and polyether impression materials have been modified by adding plasticizers and catalyst in order to be used as interocclusal recording media. These materials have become popular because of their dimensional accuracy, stability and resistance to compression. The present study was undertaken with the

Fig. 3 Jet Bite PVS interocclusal recording material

following aim and objective i.e. to compare the compression resistance of four different interocclusal recording materials under a constant load, assuming that there is no difference in the compression resistance of different recording materials as our null hypothesis.

Materials and Method

The present study was carried out in Department of Prosthodontics, K.D. Dental College & Hospital, Mathura in collaboration with Spectro Analytical Labs Limited, New Delhi.

Four different types of interocclusal recording materials viz. Imprint Bite (Fig. 1), Virtual Refill (Fig. 2), Jet Bite (Fig. 3) and Ramitec (Fig. 4) were used.

S. No	Product	Type	Supplier	Composition	Form	Batch no
1	Imprint Bite	Vinyl polysiloxane	3 M ESPE, Germany	Base paste-polymethyl hydrogen siloxane and other siloxane prepolymers, hybrid silicone, fillers	Catridge	36850
				Catalyst paste-divinyl polydimet		
2	Virtual Refill	Reflective vinylpolysiloxane	Ivoclar vivadent, Italy	Vinylpolysiloxane, methylhydrogensiloxane, organoplatinic complex, silica, pigment and food dyes	Catridge	607908
3	Jet Bite	Addition silicone	Coltene Whaledent, Switzerland	Base paste-polymethyl hydrogen siloxane and other siloxane prepolymers, hybrid silicone, fillers	Catridge	6400
				Catalyst paste- divinyl polydimet		
4	Ramitec	Polyether	3 M ESPE, Germany	Base paste- Polyether polymer, colloidal silica as filler, plasticizer such as glycolether or phthalate	Tube	33710
				Accelerator paste-alkyl aromatic sulfonate		

Fig. 4 Ramitec polyether interocclusal recording material

Method

Metallic Cylinders

A standard cylindrical Stainless Steel die, in the form of hollow cylinders which was open at both the ends, having internal diameter of 10 mm and four different length of 2, 5, 10 and 20 mm [3, 6, 7] (Fig. 5), a metallic base (Fig. 6) and a metallic plate (Fig. 7) was machine tooled for this study. The master die use for this study was based according to ADA specification No. 19 as for dental elastomeric impression materials.

Mixing of Specimen

Polyvinylsiloxane

The catridge was placed in the dispensing gun with the mixing tip attached to it and was injected into the cylindrical die.

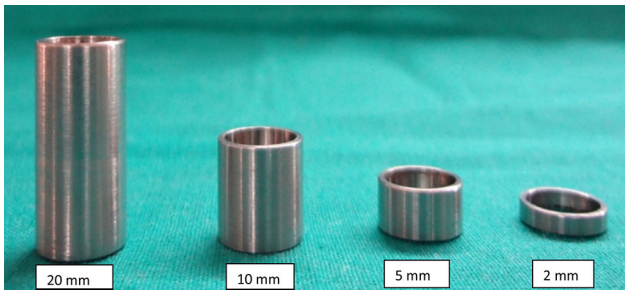


Fig. 5 Metallic cylinders

Polyether

The mixing ratio of polyether is 8.3 g base paste: 1 g catalyst paste. The paste was dispensed onto mixing pad and was measured by measuring machine. Then, it was placed on the glass slab and was mixed with a mixing spatula until a homogeneous mass of uniform colour was produced. The paste mixture was filled into the ramitec syringe and was injected into the cylindrical die.

Specimen Fabrication

Each die was coated inside with the lubricating agent as for the ease of removal of set material from it. The metallic cylinder was then attached to the metallic base from one side.

The material was injected into 10 mm diameter die of different lengths (20, 10, 5 and 2 mm) and then covered with metallic plate on top. The electronic timer was set for 2 min and the material was allowed to harden before removal from the cylinder. Five specimens of each material were fabricated in four different lengths (20, 10, 5 and 2 mm), so a total of 20 specimens of each material, and a

Fig. 6 Metallic base

Fig. 7 Metallic plate

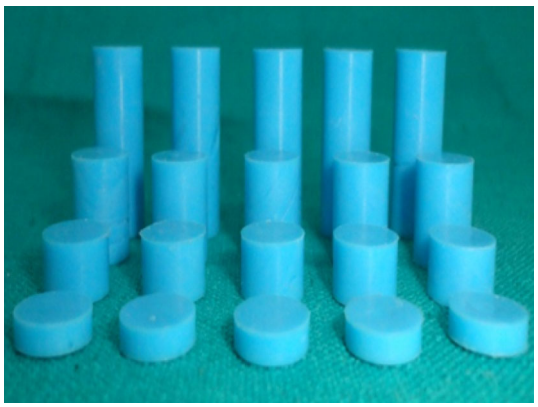


Fig. 8 Imprint bite samples

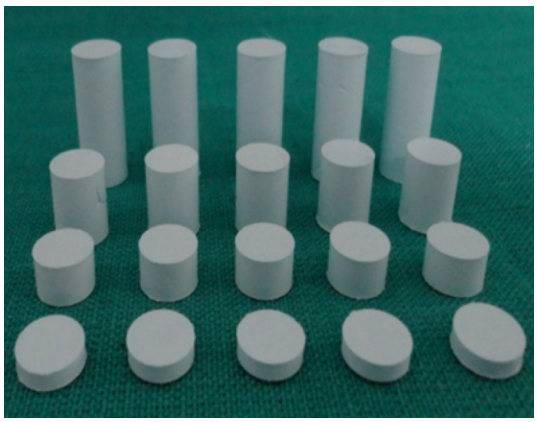


Fig. 9 Virtual Refill samples

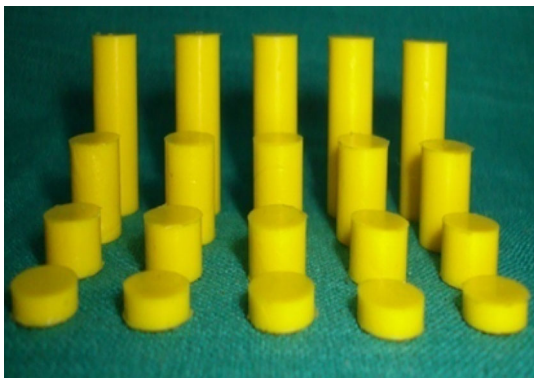


Fig. 10 Jet bite samples

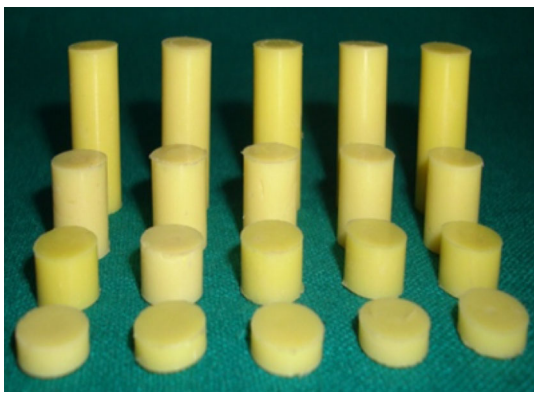


Fig. 11 Ramitec samples

total of 80 samples were fabricated. These groups were designated as Group A—Imprint Bite (Fig. 8), Group B—Virtual Refill (Fig. 9), Group C—Jet Bite (Fig. 10) Group D—Ramitec (Fig. 11). The 20 samples of each group were subdivided into four subgroups of 5 each. These subgroups were designated as Subgroup I (2 mm length), Subgroup II (5 mm length), Subgroup III (10 mm length) and Subgroup IV (20 mm length).

The specimens were fabricated in the following manner

Fig. 12 Universal testing machine

Group I : Imprint bite polyvinysiloxane bite registration material
I A: Specimens with 2 mm thickness
I B: Specimens with 5 mm thickness
I C: Specimens with 10 mm thickness
I D: Specimens with 20 mm thickness

Group II: Virtual Refill polyvinylsiloxane bite registration material
II A: Specimens with 2 mm thickness
II B: Specimens with 5 mm thickness
II C: Specimens with 10 mm thickness
II D: Specimens with 20 mm thickness

Group III: Jet Bite polyvinylsiloxane registration material
III A: Specimens with 2 mm thickness
III B: Specimens with 5 mm thickness
III C: Specimens with 10 mm thickness
III D: Specimens with 20 mm thickness

Group IV: Ramitec polyether bite registration material
IV A: Specimens with 2 mm thickness
IV B: Specimens with 5 mm thickness
IV C: Specimens with 10 mm thickness
IV D: Specimen with 20 mm thickness

Testing of the Specimens

The samples were stored in tightly sealed containers and kept for 24 h before testing. The compressive resistance

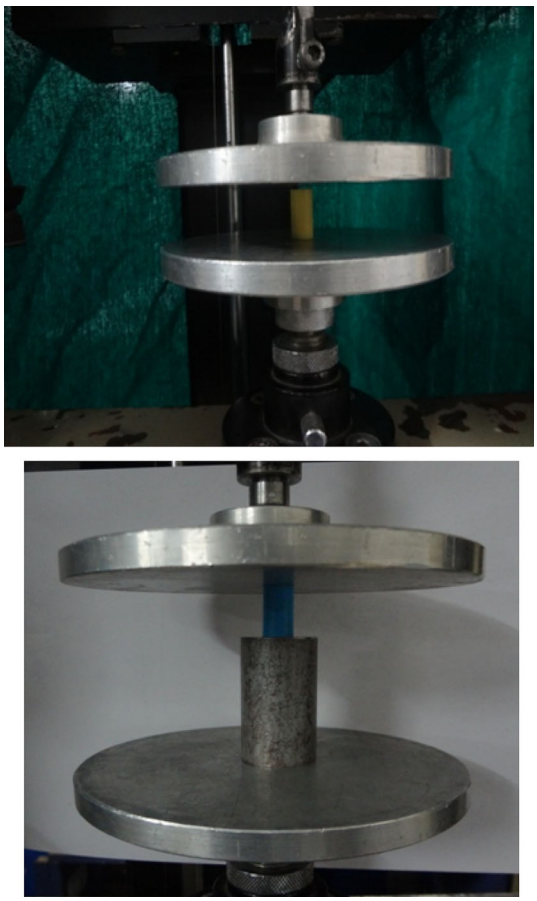


Fig. 13 Samples being tested on universal testing machine

was tested by using a universal testing machine (Fig. 12). Each of the test samples was loaded on a universal testing machine and subjected to a constant compressive force of 25 N (Fig. 13) for a duration of 1 min and the results so obtained were statistically analyzed.

Statistical Analysis

All the values of different measurements of master dies obtained from four interocclusal bite registration materials at different dimensions i.e. 2, 5, 10 and 20 mm were recorded and subjected to statistical analysis.

Results

The results of the study pertaining to the compressive resistance of the four selected interocclusal bite registration materials and the statistical evaluation are given in Tables 1, 2, 3, 4 and 5 and plotted in Graph 1, 2, 3 and 4.

Table 1 Comparison of compression distance values in mm of Group I specimens (Imprint Bite) at various thicknesses

Thickness (mm)	*N*	Mean (mm)	SD	SEM	Variance	CV
2	5	0.082	0.025884	0.011576	0.00067	31.56629
5	5	0.136	0.040373	0.018055	0.00163	29.68622
10	5	0.236	0.04219	0.018868	0.00178	17.87714
20	5	0.442	0.037014	0.016553	0.00137	8.374098

Table 2 Comparison of compression distance values in mm of Group II specimens (Virtual Refill) at various thicknesses

Thickness (mm)	*N*	Mean (mm)	SD	SEM	Variance	CV
2	5	0.044	0.023022	0.010296	0.00053	52.32211
5	5	0.104	0.015166	0.006782	0.00023	14.58245
10	5	0.186	0.050299	0.022494	0.00253	27.04253
20	5	0.39	0.047434	0.021213	0.00225	12.16261

Table 3 Comparison of compression distance values in mm of Group III specimens (Jet Bite) at various thicknesses

Thickness (mm)	*N*	Mean (mm)	SD	SEM	Variance	CV
2	5	0.186	0.029665	0.013266	0.00088	15.94881
5	5	0.386	0.094499	0.042261	0.00893	24.48152
10	5	0.51	0.043589	0.019494	0.0019	8.546861
20	5	0.946	0.204402	0.091411	0.04178	21.60693

Table 4 Comparison of compression distance values in mm of Group IV specimens (Ramitec) at various thicknesses

Thickness (mm)	*N*	Mean (mm)	SD	SEM	Variance	CV
2	5	0.1	0.015811	0.007071	0.00025	15.81139
5	5	0.152	0.029439	0.013166	0.000867	19.3679
10	5	0.29	0.053385	0.023875	0.00285	18.40876
20	5	0.578	0.014832	0.006633	0.00022	2.566159

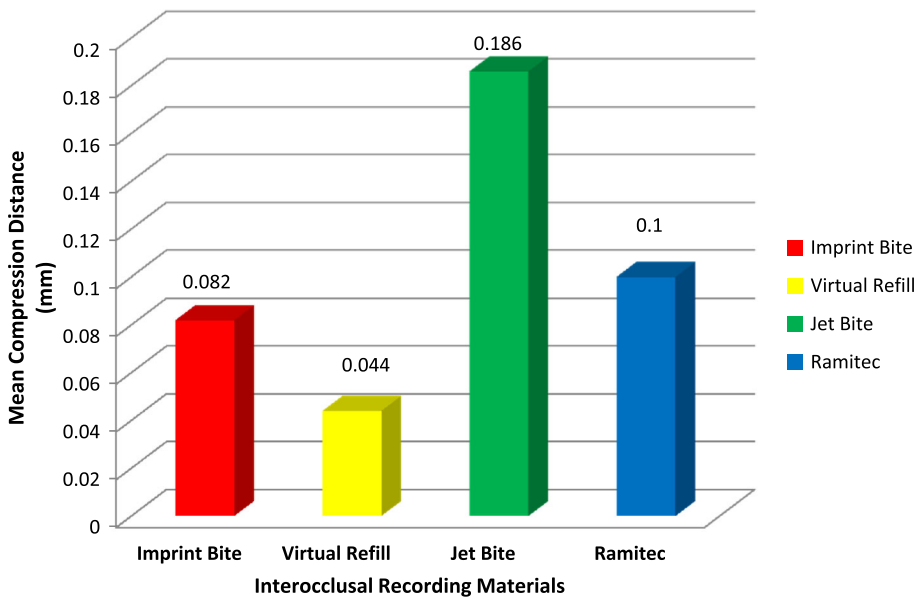
Table 5 Two way ANOVA with post hoc test comparison of compression of different interocclusal recording materials

Two-way ANOVA analysis						
Source of variation	SS	*df*	MS	*F*	*p* value	*F* crit
Sample	2.63	3.00	0.88	204.50	0.00	2.75
Columns	1.26	3.00	0.42	97.86	0.00	2.75
Interaction	0.29	9.00	0.03	7.41	0.00	2.03
Within	0.27	64.00	0.00			
Total	4.44	79.00				

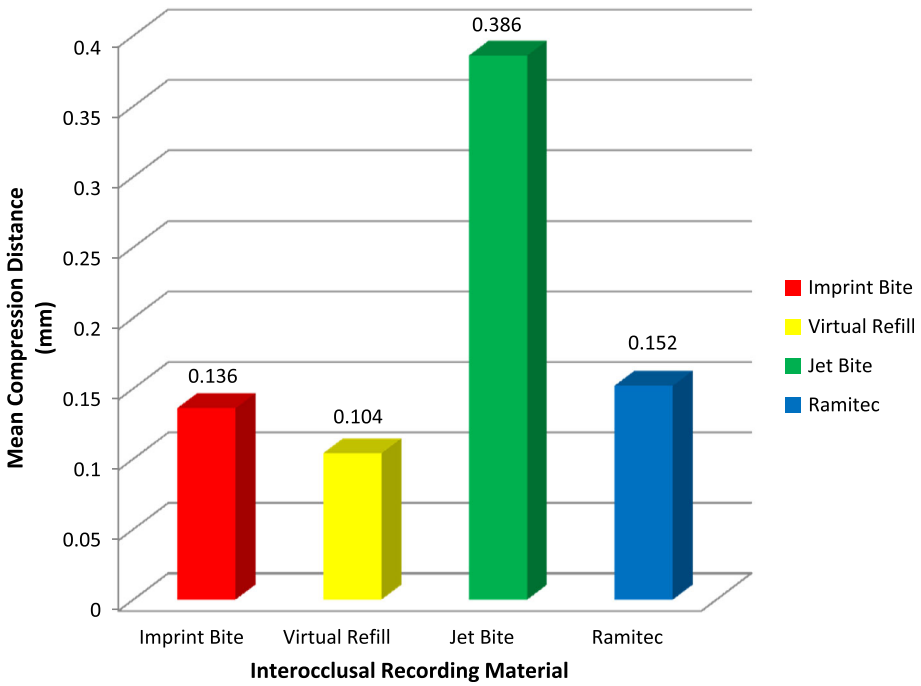
Descriptive data included mean, standard deviation, coefficient of variation and range values of the groups. Comparisons between the groups and within the groups were done by applying two-way ANOVA. *p* value of less than 0.05 was considered as statistically significant.

The compression resistance of the four interocclusal bite recording materials is discussed as under. The findings of the study showed 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, 2, 3, 4 for all the four materials tested. This observation conclude that as the thickness increases, compression also increases. This was in accordance with the studies of Breeding LC, Dixon DL who showed that thicker elastomeric interocclusal registration media are generally more compressible.

Results of two-way analysis of variance ($\alpha < 0.05$) indicated that there was a significant difference in compressive resistance among the materials of each thickness as tabulated in Table 5. According to the findings of this study, *p* value was <0.05 so it was statistically significant and hence the null hypothesis was rejected.



Graph 1 Comparison of compression resistance between different interocclusal recording materials of 2 mm thickness

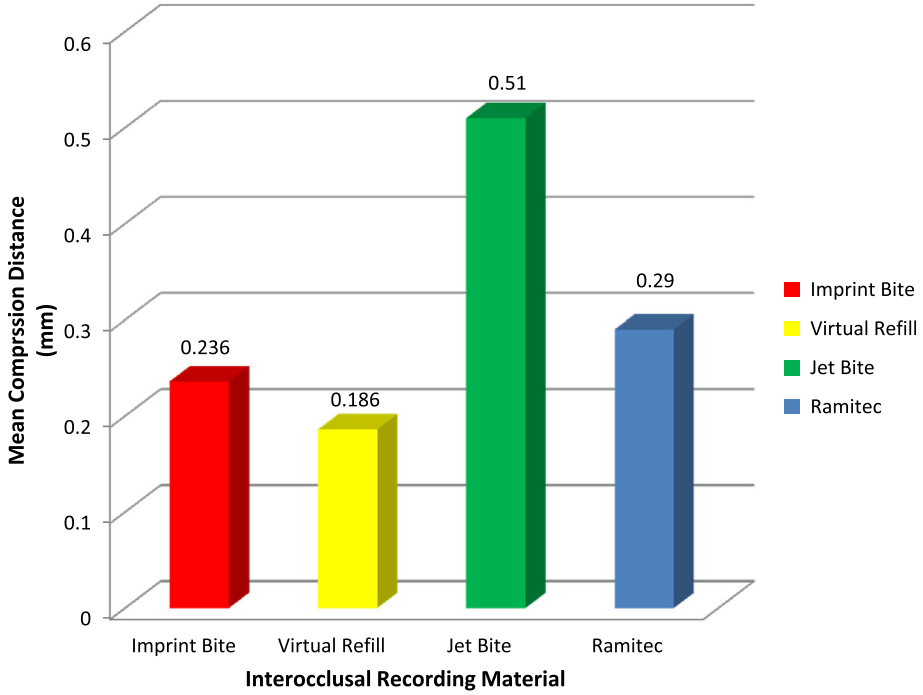


Graph 2 Comparison of compression resistance between different interocclusal recording materials of 5 mm thickness

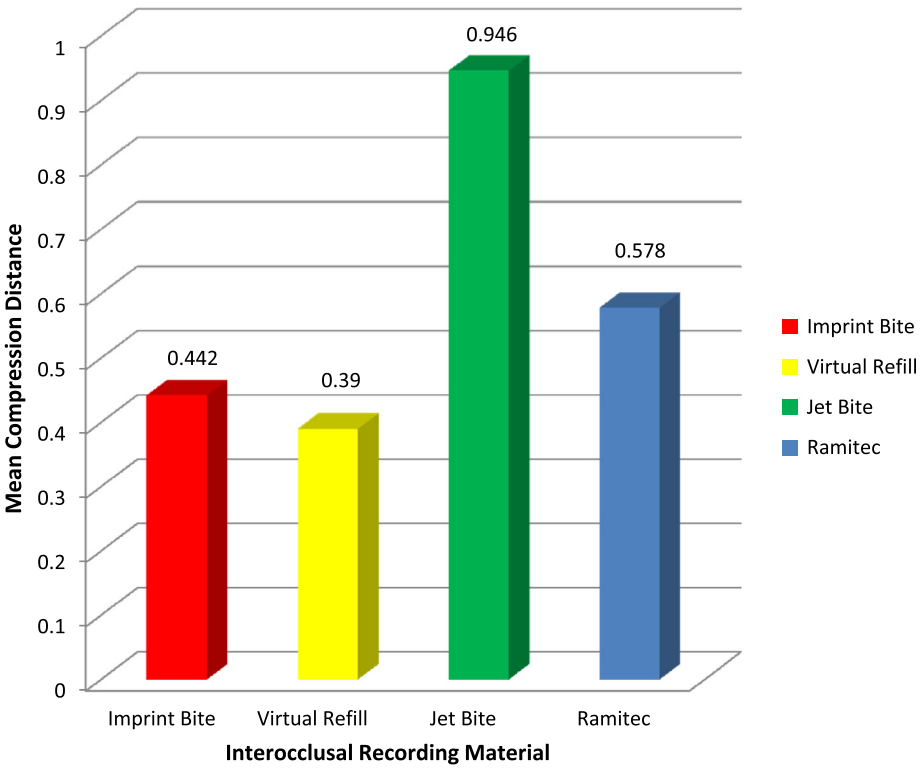
Discussion

Interocclusal record is a registration of the positional relationship of the opposing teeth or arches. An ideal interocclusal record allows the intraoral placement of restorations without extensive adjustments. It is necessary to record the maxillomandibular relationship and accurately transfer it to the articulator [8]. There are various methods of recording maxillomandibular relationships viz, graphic, functional, cephalometric and direct interocclusal recordings [9]. Direct interocclusal records are most commonly used to record maxillomandibular relationships because of their simplicity. The arches are brought into a relationship with or without tooth contact, and a space is created between the teeth. The recording material, which is initially soft, fills the spaces between teeth, hardens, and records the specific relationship of the arches. The hardened material is then transferred onto casts to be mounted on an articulator [10].

One of the most desirable characteristics of the interocclusal registration material is resistance to compression after polymerization. The material should be rigid enough



Graph 3 Comparison of compression resistance between different interocclusal recording materials of 10 mm thickness



Graph 4 Comparison of compression resistance between different interocclusal recording materials of 20 mm thickness

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 casts during the mounting procedure [11]. The ability of an interocclusal registration material to resist compressive forces is very important because any discrepancy between the intraoral relationships of the teeth and the position of the teeth on the mounted working casts will result in restorative errors [3].

In the present study compressive resistance of four interocclusal recording materials viz. Imprint bite, Vitual

refill, Jet bite and Ramitec at various thickness (2, 5, 10 and 20 mm) when subjected to a constant compressive load was studied. The thickness of the interocclusal recoding materials were selected to simulate various clinical situations. For standardization, the specimens were stored at room temperature for 24 h to simulate the time between clinical and laboratory phases.

Rubber bands are commonly used to sustain the contact of opposing casts during mounting procedures. The maximal force exerted by use of one office standard rubber band (No. 19) to a position a maxillary cast to a mandibular cast mounted on an articulator was approximately 25 N, so this value was selected in the investigation [3].

Twenty specimens of each material were obtained and divided into four subgroups: Specimens with 2, 5, 10 and 20 mm thickness. After fabrication, each specimen was subjected to a constant compressive force of 25 N by means of the Universal testing machine for 1 min.

Among the 2 mm thickness specimens, Virtual Refill bite registration material showed the least compression value (0.04 mm) than Imprint bite polyvinylsiloxane registration material (0.08 mm), Ramitec polyether bite registration material (0.10) and Jet bite polyvinylsiloxane registration material (0.18 mm) as plotted in Graph 1.

In Graph 2, samples of the 5 mm thickness, Virtual Refill bite registration material showed the least compression distance value (0.10 mm) when compared to Imprint bite polyvinysiloxane registration material (0.13 mm), Ramitec polyether bite registration material (0.15 mm) and Jet bite polyvinylsiloxane registration material (0.38 mm).

On the basis of results seen in Graph 3, samples of the 10 mm thickness, Virtual Refill bite registration material showed the least compression value (0.18 mm) than Imprint bite polyvinysiloxane registration material (0.23 mm), Ramitec polyether bite registration material (0.29 mm) and Jet bite polyvinylsiloxane registration material (0.51 mm).

Similarly, in Graph 4, samples of the 20 mm thickness, Virtual Refill bite registration material showed the least compression distance value (0.39 mm) when compared to Imprint bite polyvinysiloxane registration material (0.44 mm), Ramitec polyether bite registration material (0.57 mm) and Jet bite polyvinylsiloxane registration material (0.94 mm).

The results of the foregoing study indicated 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. This observation was in correlation with the studies of Breeding LC, Dixon DL [3] who showed that Blue Mousse polyvinylsiloxane displayed the greatest resistance to compression as compared to other elastomeric interocclusal recoding materials in their study.

Different methods of articulation have been proposed. Modification of the Jones bite frame technique described by Huffman, Regenos and Taylor involves the use of an anterior jig. The recording material, a zinc oxide and eugenol paste, is carried to the mouth on thin fiberglass mesh luted to a wire frame with soft wax. A method described by Wirth and Aplin, and the recording material is Aluwax, which is reinforced with ash's metal. The completed record has a chilled Aluwax anterior stop to prevent tooth contact. A technique described by Boucher uses impression plaster as recording material and the patient is asked to pull his lower jaw back as far as he can and close into the recording material. In a technique formerly used by Stuart, the recording material is autopolymerizing acrylic resin. The end of a tongue blade or Popsicle stick is inserted between the incisors as the subject closes into the recording material and the dentist pries slightly downward and backward to encourage posterior closing. Myocentric positional records were made using the Jankelson Myo Monitor. The recording material is Sapphire Myo-Print imprint plastic and the for establishing the occlusal position the casts can be hand articulated with maximum intercuspation of teeth. It is concluded that the least variable of all methods for mounting the mandibular cast was in which the casts were hand articulated in maximum intercuspation (occlusal position or centric occlusion) [12].

From the previous studies, it is concluded that wax and zinc oxide eugenol are not reliable as interocclusal registration materials, because of the great linear changes these materials present even from the first hour and there are possible mounting inaccuracies that may develop if they are not used immediately after the interocclusal registration procedure [13].

The flow of the wax depends largely on the temperature, the applied force, and the duration of the force application. The difficulties encountered in wax manipulation as well as the special instrumentation needed are the major disadvantages of this material, when compared to the new elastomeric bite registration media [14].

Zinc oxide eugenol paste dehydrates, cracks and sticks to the teeth; and vital portions of the record can be lost through breakage. Once a zinc oxide eugenol record has been used to mount casts, it is rarely used again. Unless trimmed, the flash around the teeth can prevent the accurate seating of casts, so it is advisable to use a minimum amount of zinc oxide eugenol to avoid excess flash [15].

On the other hand, polyether and polyvinylsiloxane do not seem to be so time sensitive, and as a result are more appropriate for the registration of maxillomandibular relationships.

In this study Virtual Refill polyvinylsiloxane bite registration material showed greater resistance to compression than Ramitec, Imprint Bite and Jet Bite interocclusal

registration material. The reason for the greater compression resistance of Virtual Refill bite registration material may be because of its low dimensional change compared to other bite registration material [16].

Virtual Refill composed of methylhydrogensiloxane, organoplatinic complex which imparts better properties as compare to Imprint bite and Jet Bite. That is why, Imprint bite and Jet bite had poor values and had less compression resistance as compare to Virtual Refill interocclusal recording material.

From this study the most important observation was that there were significant difference in the dimensions of all the samples at various thickness obtained from all the four interocclusal bite registration materials under a constant compressive load.

The present study was undertaken with the following aim and objective i.e. to compare the compression resistance of four different interocclusal recording materials under a constant load, assuming that there is no difference in the compression resistance of different recording materials as our null hypothesis. According to the findings of this study, p value was <0.05 so it was statistically significant and hence the null hypothesis was rejected.

The results of foregoing study showed that Virtual Refill polyvinylsiloxane bite registration material having greater resistance to compression than other interocclusal recording material at various thickness, with negligible error of 0.04 mm found in 2 mm thickness. Correct interocclusal records would result in castings with suitable occlusal contacts on the articulator give clinician the opportunity to make only minimal adjustments to the restorations that were delivered from the laboratory and avoid unnecessary use of chairtime, or repetition of some clinical and technical stages. It is mandatory to chose a material not only depending on the clinical situation but also based on the time taken for the articulation. When elastomeric interocclusal recording materials are used to mount working casts, minimal pressure should be exerted on the articulated casts during mounting, the record should be a minimal thickness; and an optimal recording material should exhibit minimal distortion during compression.

Conclusion

From the results of foregoing 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. Virtual refill reflective polyvinylsiloxane bite registration material exhibited the greatest resistance to compression than the other materials at thicknesses of 2, 5, 10 and 20 mm.

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