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An In Vitro Study to Evaluate and Compare, The Compression Resistance of Two Types of Elastomeric Interocclusal Record Materials at Different Thicknesses, When Subjected to A Constant Load

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ABSTRACT
Aim : To evaluate and compare, the compression resistance of two types of elastomeric interocclusal record materials, measured at different thicknesses, when subjected to a constant load.
Setting and Design: In vitro study.
Material and Methods : This in vitro study was conducted on 30 cylindrical samples, having an internal diameter of 20 mm and of three different heights of 2, 5, and 10mm. The samples were divided in two groups I and II, consisting of 15 samples each. Group I samples were made from Material I i.e. Polyvinylsiloxane Bite Registration Paste and divided according to the height as, Group Ia – Polyvinylsiloxane samples of 2mm thickness. Group Ib –Polyvinylsiloxane samples of 5mm thickness.Group Ic –Polyvinylsiloxane samples of 10mm thickness. Group II samples were made from Material II i.e., Polyether Bite Registration Paste and divided as Group IIa – Polyether samples of 2mm thickness. Group IIb – Polyether samples of 5mm thickness. Group IIc – Polyether samples of 10mm thickness. The samples, stored in tightly sealed containers and kept for 24 hours before testing. The compression resistance of all the samples was evaluated using an Instron Universal Testing Machine. The values were noted as deflections of each sample. These results were tabulated and then statistically analysed.
Statistical Analysis Used : Kolmogorov-Smirnov and Shapiro-Wilk tests, ANOVA test
Tukey's multiple comparison test.
Results : According to the findings of this study, p value, for comparison within the Group II samples was < 0.05; i.e. a statistically significant difference existed between the compression resistance of IIa and IIc samples. Whereas for the comparisons between the two groups as well as for the comparisons between the subgroups of Group I samples, the p value was found to be>0.05. Hence the null hypothesis was acceptedthat there were significant difference in the dimensions of all the samples at various thickness obtained from both the interocclusal bite registration materials under a constant compressive load.Although numerically, interocclusal bite registration records when having the least thickness – go through the least compression; it has been observed in this study that the compressibility of polyether as well as polyvinylsiloxane bite registration records, decreases as the thickness increases.
Conclusion : Polyvinylsiloxane interocclusal bite registration material, at 10mm thickness (group Ic), shows more resistance to compression than at 5mm thickness (group Ib) and least at 2mm thickness (group Ia).Polyether interocclusal bite registration material, at 10mm thickness (group IIc), shows more resistance to compression than at 5mm thickness (group IIb) and least at 2mm thickness (group IIa). The resistance to compression for both the materials, at 2mm thickness (groups Ia&IIa) was found to be similar. The resistance to compression at 5mm thickness, was found to be more with the polyvinylsiloxane bite registration material (group Ib) as compared to the polyether bite registration material (group IIb). The resistance to compression at 10mm thickness, was found to be more with the polyvinylsiloxane bite registration material (group Ic) as compared to the polyether bite registration material (group IIc).
Keywords: Interocclusal record material, compression resistance, bite registration.

Introduction:

It is important to achieve harmony between the maxillomandibular relationship of the patient and the final prosthesis, for achieving successful, functional, and aesthetic restoration.[1] Recording and transferring of accurate existing occlusal records is of prime importance for a successful restoration. Precise articulation of the patient's cast is a prerequisite for the purpose of diagnosis and subsequent corrective treatment. Interocclusal bite registration materials are hugely responsible for accurate treatment planning and occlusal precision of the final prosthetic restorations, when used for mounting casts on the articulators.[2] Accurate mountings can lead to restorations that require minimal occlusal modifications intraorally, thus reducing the chairside time. Apart from the operator's clinical ability and the technique followed, the material used can critically affect the accuracy of interocclusal registration.[3] The ideal material-technique combination for making interocclusal records would allow the placement of indirectly fabricated prostheses in the patient's mouth with no occlusal adjustment. There is little scientific evidence to prove the superiority of one material-technique combination over another. 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] The ability of an interocclusal recording material to resist compressive force is critical because of the potential for the inaccuracies in mounting.[5] Interocclusal recording of the relationship of the mandible to the maxilla is a simple but a complex procedure. 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.[6] Recent additions, like 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.[7]The interocclusal record describes the vertical and horizontal relationship of the maxillary and mandibular teeth. In circumstances where the vertical relationship is not supported through a tripod of widely spaced opposing contacts, the interocclusal record will be needed to restore this vertical support to prevent inaccurate mounting.[12] The clinician should understand when an interocclusal record is required and have an awareness of the different materials and techniques available to record an interocclusal registration.[13]However, since there were many disadvantages of using traditional interocclusal recording materials, Elastomeric interocclusal recording materials were introduced. Elastomeric materials are the most dimensionally stable materials till now. Elastomeric materials as interocclusal record materials consistently yielded the least error amongst the materials studied. They are easy to manipulate and offer little or no resistance to closure, good stability after polymerization and during storage, high accuracy of details recorded and a good shelf-life.[14]Two types of silicone elastomeric materials are available as interocclusal recording materials – condensation silicone and addition silicone. Among the elastomers, addition silicones exhibit least amount of distortion. Polyether interocclusal registration material consists of the basic impression material ingredients augmented by plasticizers and fillers. The advantage of this material as an interocclusal recording material are accuracy, stability after polymerization and during storage, fluidity, and minimal resistance to closure, can be used without a carrier.[15]After the interocclusal records had been made, the casts must be secured together with the recording medium positioned between them for mounting on an articulator. A compressive force is commonly exerted on the elastic recording material during this procedure and may cause inaccuracies during mounting of the casts and distortions during fabrication of the restorations.[16] The ability of an interocclusal recording material to resist compressive forces is thus, critical because of the potential for these inaccuracies to get incorporated.[17]Therefore, this in-vitro study was planned to compare the deformation of three different thicknesses of two elastomeric interocclusal recording materials, i.e. Polyvinylsiloxane and Polyether interocclusal recording materials, when subjected to a constant compressive load and thus to find the material which can resist a constant compressive load and will give the least inaccuracies.[18] The thicknesses of the interocclusal recording materials were selected to simulate various clinical situations.The Nulls hypothesis was that thereisnon-significantdifferenceintheresistance to compression between Groups I and Group II under study.Alternate Hypothesis was that polyether interocclusal bite registration material is more resistant to compression than Polyvinylsiloxane interocclusal bite registration material.

Objectives

1. To evaluate the compression resistance of2mm, 5mm and 10mm thicknesses of the Polyvinylsiloxane interocclusal recording material when subjected to 25N of force for 60 seconds.
2. To evaluate the compression resistance of2mm, 5mm and 10mm thicknesses of the Polyether interocclusal recording material when subjected to 25N of force for 60 seconds.
3. To compare the compression resistance of 2mm, 5mm and 10mm thicknesses of Polyvinylsiloxane and Polyether interocclusal recording materials when subjected to 25N of force for 60 seconds.

Materials and methods

In the present study, 30 interocclusal bite registration material samples were fabricated usinga standard cylindrical plastic master die, in the form of hollow cylinder, which is open at both the ends, having an internal diameter of 20 mm and of three different heights of 2, 5, and 10mmwith two different materials (Polyvinylsiloxane and Polyether). The master die used for this study was according to ADA specification No.19 (4.3.6) for dental elastomeric impression materials.

The samples were divided in two groups I and II, consisting of 15 samples each. Group I samples was made from Material I i.e., Polyvinylsiloxane Bite Registration Paste, and Group II samples was made from Material II i.e., Polyether Bite Registration Paste. They were further grouped as follows-

Table 1: Randomization of sample

Samples	The material used and thickness
Group Ia	Polyvinylsiloxane samples of 2mm thickness.

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Group Ib	Polyvinylsiloxane samples of 5mm thickness.
Group Ic	Polyvinylsiloxane samples of 10mm thickness.
Group IIa	Polyether samples of 2mm thickness
Group IIb	Polyether samples of 5mm thickness
Group IIc	Polyether samples of 10mm thickness

Fig. 1– Moulds to prepare samples

Fig. 2– Polyvinylsiloxane biteregistration paste

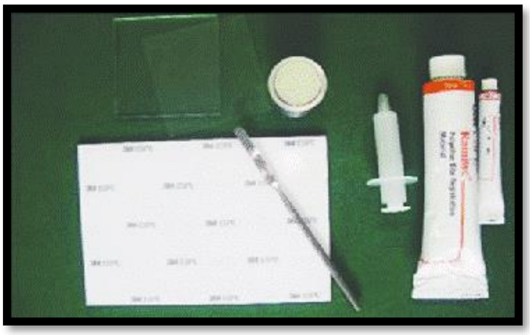

Fig. 3 – Polyether biteregistration paste

Fig. 4 – Group I (Polyvinylsiloxane) samples

Fig. 5– Group II (Polyether) samples

All the samples, stored in tightly-sealed containers were kept for 24 hours before testing. An Instron Universal Testing Machine was used to evaluate the compression resistance of all the samples. Each of the test samples was loaded on the universal testing machine and subjected to a constant compressive force of 25 N for a duration of 60 seconds. The compression, that each sample underwent, at the end of 60 seconds of compression under 25N force, was measured by the Universal Testing Machine digitally, by giving the difference between the before compression thickness and after compression thickness of each sample. These differences were noted as deflections of each sample. These results were tabulated and then statistically analyzed. ANOVA test was used to compare the significance of the difference between the samples of thickness 2mm, 5mm, and 10mm.To find out the exact significance Tukey's multiple comparison test was used.

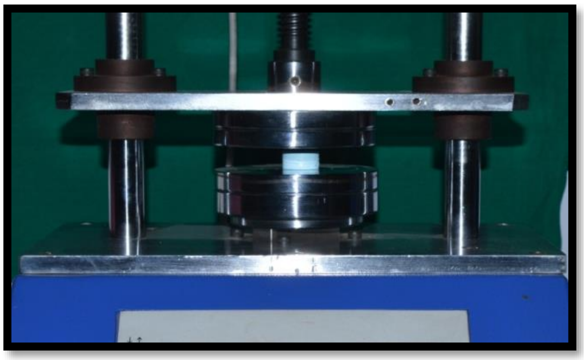

Fig.6 – Testing of the samples using instron universal testing machine

Results

Tables 1 and 2 are the observed values of thickness of Group I and Group II samples respectively, after having been subjected to 25N load for 60 seconds and the compression each sample undergoes. Table 3 is a group I samples analyzed for mean compression afterload which is represented by Graph 1. Table 4 is the mean values of the undergone compressions after 60 seconds of 25N constant load for each subgroup in group I samples. Table 5 is group II samples analysed for mean compression afterload which is represented by Graph 2. Table 6 is the mean values of the undergone compressions after 60 seconds of 25N constant load for each subgroup in group II specimens. Table 7 is the mean values of the undergone compression for the subgroup of 2mm specimens in both the groups which is represented by Graph 3. Table 8 is the mean values of the undergone compression for the subgroup of 5mm specimens in both the groups which is represented by Graph 4. Table 9 is the mean values of the undergone compression for the subgroup of 10mm specimens in both the groups which are represented by Graph 5.

TABLE 1 GROUP I (POLYVINYLSILOXANE BITE REGISTRATION MATERIAL) THICKNESS MEASUREMENTS AFTER 60 SECONDS UNDER 25N CONSTANT LOAD

	Ia (2mm)	**Ib (5mm)**	**Ic (10mm)**
SAMPLE 1	1.8mm	5mm	10mm
Compression	0.2mm	0mm	0mm
SAMPLE 2	1.5mm	4.5mm	9.7mm
Compression	0.5mm	0.5mm	0.3mm
SAMPLE 3	1.9mm	4.8mm	9.2mm
Compression	0.1mm	0.2mm	0.8mm
SAMPLE 4	1.8mm	4.5mm	9.6mm
Compression	0.2mm	0.5mm	0.4mm
SAMPLE 5	1.7mm	4.7mm	9.4mm
Compression	0.3mm	0.3mm	0.6mm

TABLE 2 GROUP II (POLYETHER BITE REGISTRATION MATERIAL) THICKNESS MEASUREMENTS AFTER 60 SECONDSUNDER 25N CONSTANT LOAD

	IIa (2mm)	**IIb (5mm)**	**IIc (10mm)**
SAMPLE 1	1.7mm	4.5mm	9.2mm
Compression	0.3mm	0.5mm	0.8mm
SAMPLE 2	1.7mm	4.5mm	9.4mm
Compression	0.3mm	0.5mm	0.6mm
SAMPLE 3	1.8mm	4.7mm	9.5mm
Compression	0.2mm	0.3mm	0.5mm
SAMPLE 4	1.8mm	4.6mm	9.3mm
Compression	0.2mm	0.4mm	0.7mm
SAMPLE 5	1.7mm	4.8mm	9.35mm
Compression	0.3mm	0.2mm	0.65mm

TABLE 3 GROUP I SAMPLES ANALYSED FOR MEAN COMPRESSION AFTER LOAD

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	d.f.	p-value	Statistic	d.f.	p-value
2mm (Ia)	0.254	5	0.200	0.914	5	0.492
5mm (Ib)	0.227	5	0.200	0.910	5	0.468
10mm(Ic)	0.146	5	0.200	0.992	5	0.985

TABLE 4 MEAN VALUES OF THE UNDERGONE COMPRESSIONS AFTER 60 SECONDS OF 25N CONSTANT LOAD FOR EACH SUBGROUP IN GROUP I SAMPLES

	Mean	Compressibility	SD
2 mm (Ia)	0.26	13%	0.15
5 mm (Ib)	0.30	6%	0.21
10 mm (Ic)	0.42	4.2%	0.30

TABLE 5 GROUP II SAMPLES ANALYSED FOR MEAN COMPRESSION AFTER LOAD

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	d.f.	p-value	Statistic	d.f.	p-value
2 mm(IIa)	0.367	5	0.026*	0.684	5	0.006*
5 mm(IIb)	0.221	5	0.200	0.902	5	0.421

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10mm(IIc)	0.127	5	0.200	0.999	5	1.000

TABLE 6 MEAN VALUES OF THE UNDERGONE COMPRESSIONS AFTER 60 SECONDS OF 25N CONSTANT LOAD FOR EACH SUBGROUP IN GROUP II SPECIMENS

	Mean	Compressibility	SD
2 mm (IIa)	0.26	13%	0.05
5 mm (IIb)	0.38	7.6%	0.13
10 mm (IIc)	0.65	6.5%	0.11

TABLE 7 MEAN VALUES OF THE UNDERGONE COMPRESSION FOR THE SUBGROUP OF 2MM SPECIMENS IN BOTH THE GROUPS

	n	Mean	Std. Deviation
Group Ia	5	0.26	0.15166
Group IIa	5	0.26	0.05477

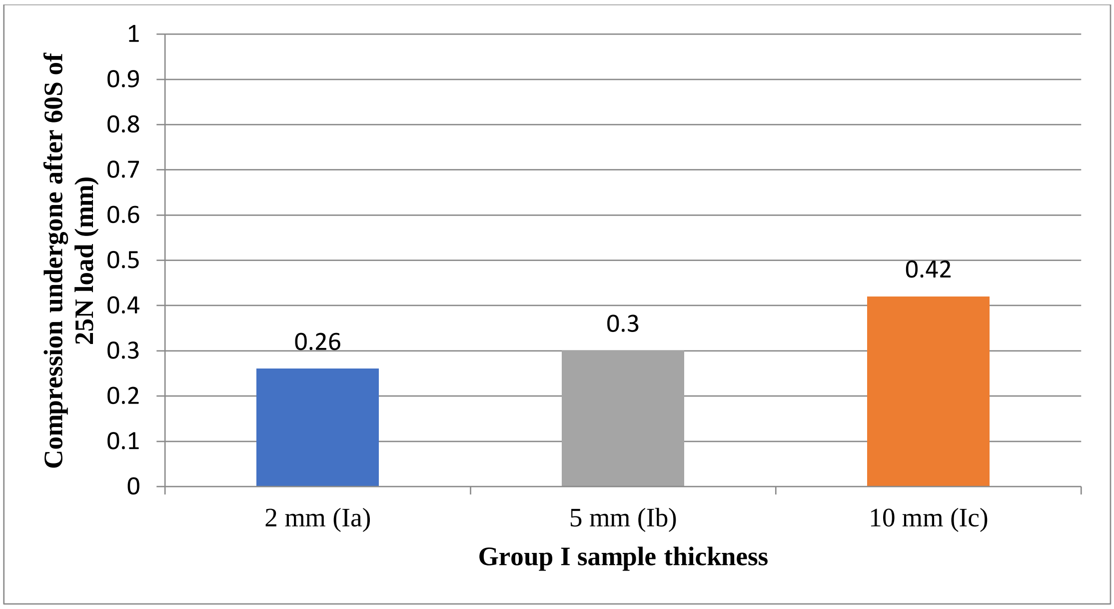
TABLE 8 MEAN VALUES OF THE UNDERGONE COMPRESSION FOR THE SUBGROUP OF 5MM SPECIMENS IN BOTH THE GROUPS

	n	Mean	Std. Deviation
Group Ib	5	0.3	0.21213
Group IIb	5	0.38	0.13038

TABLE 9 MEAN VALUES OF THE UNDERGONE COMPRESSION FOR THE SUBGROUP OF 10MM SPECIMENS IN BOTH THE GROUPS

	n	Mean	Std. Deviation
Group Ic	5	0.42	0.3033
Group IIc	5	0.65	0.1118

GRAPH 1 COMPARISON OF MEAN COMPRESSION UNDERGONE BY THE SUBGROUPS IN GROUP I SPECIMENS



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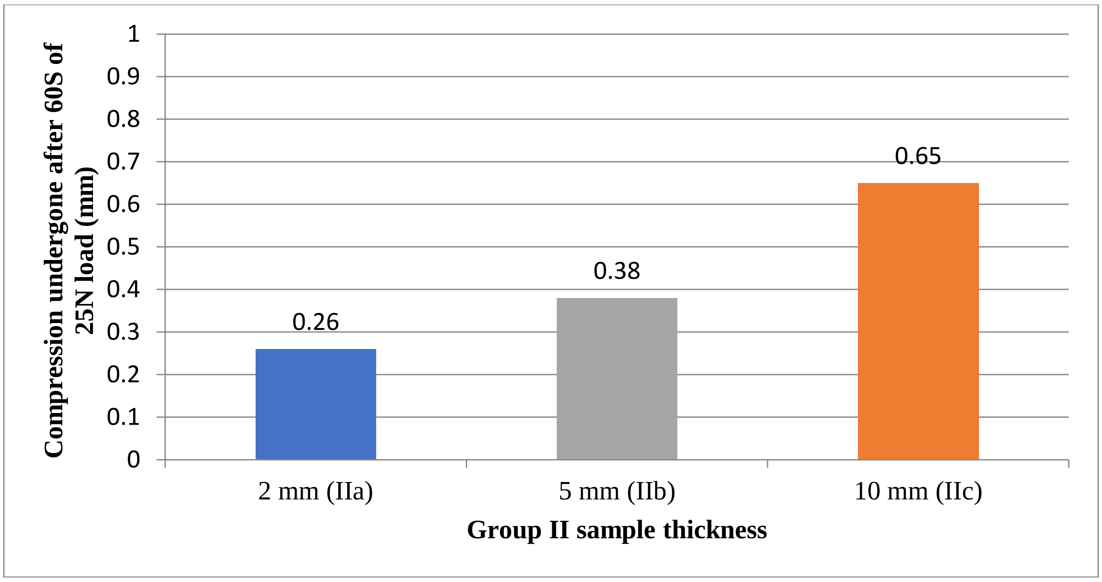
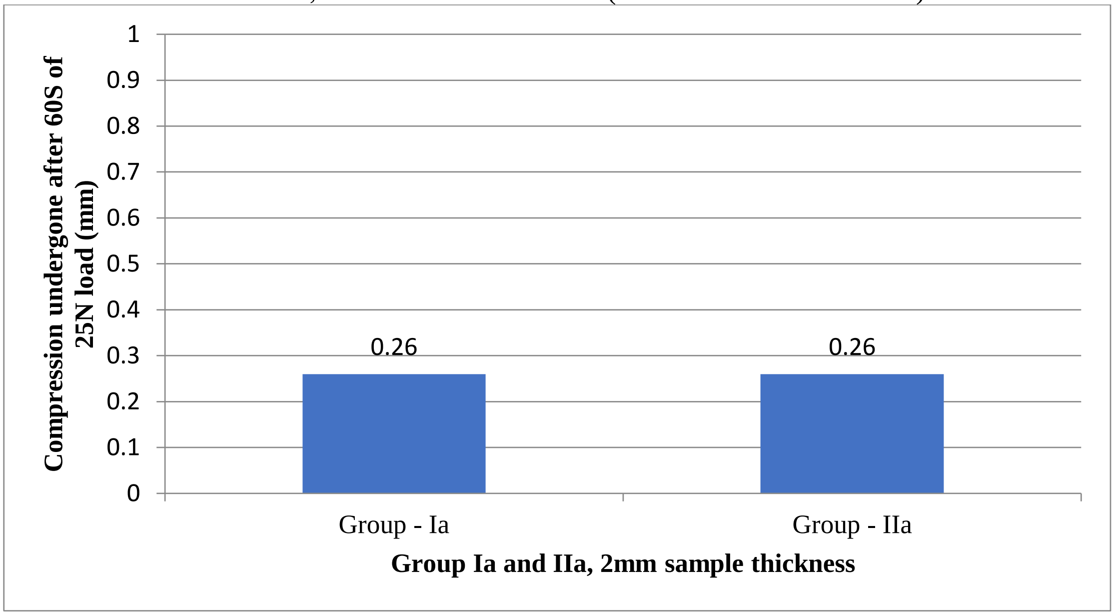
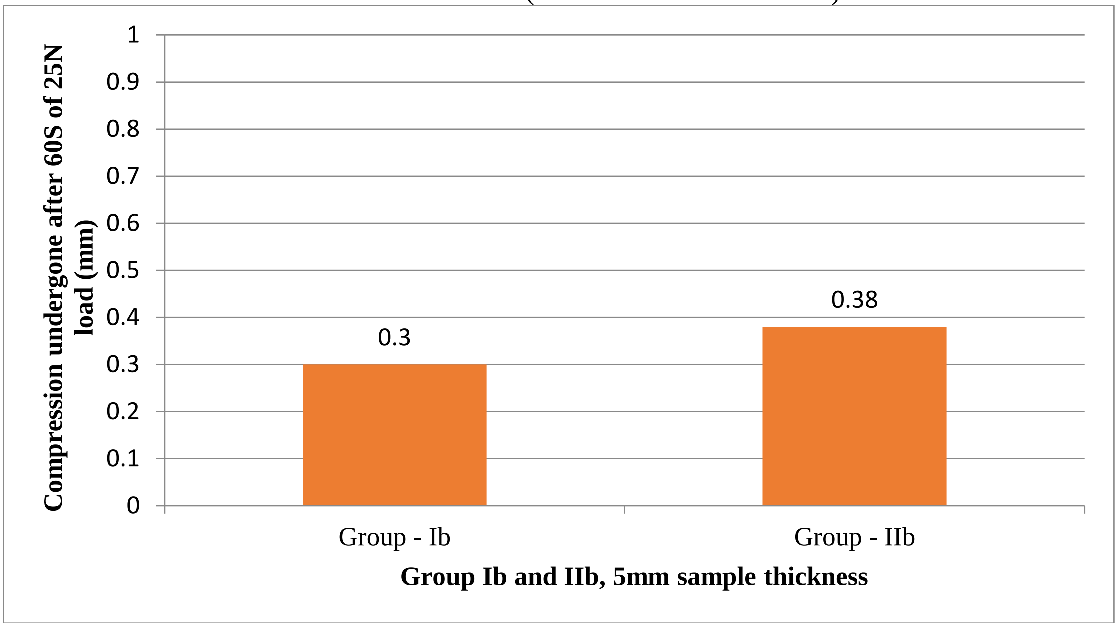
GRAPH 2 COMPARISON OF MEAN COMPRESSION UNDERGONE BY THE SUBGROUPS IN GROUP II SPECIMENS



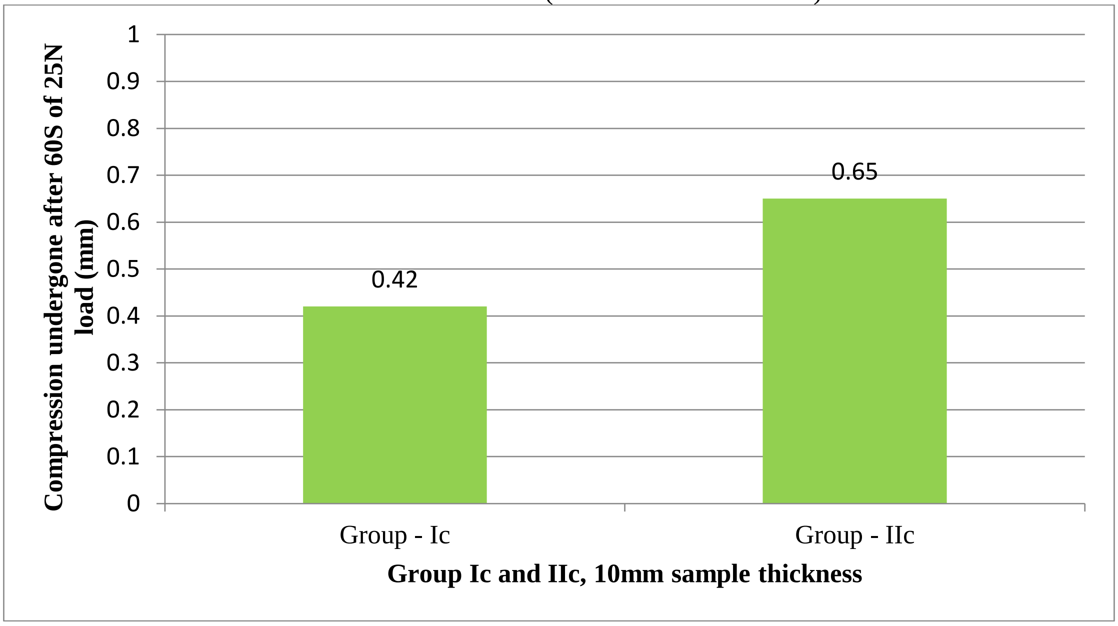
GRAPH 3 COMPARISON OF THE MEAN COMPRESSION UNDERGONE OF THE SUBGROUP OF 2MM SAMPLES, IN BOTH THE GROUPS (SUBGROUPS IA AND IIA)



GRAPH 4 COMPARISON OF THE MEAN COMPRESSION UNDERGONE OF THE SUBGROUP OF 5MM IN BOTH THE GROUPS (SUBGROUPS IB AND IIB)



GRAPH 5 COMPARISON OF THE MEAN COMPRESSION UNDERGONE OF THE SUBGROUP OF 10MM IN BOTH THE GROUPS (SUBGROUPS IC & IIC)



Discussion

The results of this study indicated that polyvinylsiloxane bite registration material showed greater resistance to compression than the other interocclusal record material in the 2mm, 5mm and 10mm thickness groups.The mean of the difference in the thickness, before and after undergoing a compression under 25N for 60s, was found to be the largest in the Group Ic samples. With a mean thickness of 9.58mm after compression, the mean compression undergone by group Ic samples is 0.42 mm, i.e. 4.2% of its original thickness. With a mean thickness of 1.74 mm after compression and a mean compression undergone of 0.26 mm, specimens in Group Ia have undergone compression of 13% of its original dimension as compared to Group Ib specimens which have a mean thickness of 4.7mm after compression and a mean compression undergone of 0.3 mm, which is 6% of its original thickness. From this we can infer, that although numerically, that the samples of least thickness (Ia) undergo least compression (0.26 mm) as compared to samples of

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greater thicknesses (Ib and Ic) , the ratio of distortion (compression : original thickness) it undergoes (13%) is higher than the the samples of greater thicknesses (6% and 4.2%). That is to say, as the thickness of the sample increases, it shows lesser (6% for Ib samples) and least (4.2% for Ic samples) compressibility. With a mean thickness of 9.35mm after compression and thus a mean undergone compression of 0.65mm, the samples in group IIc have undergone a compression of 6.5%. With a mean thickness of 1.74mm after compression and thus a mean compression undergone of 0.26mm, specimens in Group IIa have undergone a compression of 13% as compared to Group IIb specimens which have a mean thickness of 4.62mm after compression and thus a mean compression undergone of 0.38mm, which is 7.6% of its original thickness. From this we can infer, that an interocclusal record made with polyether material, although numerically may show greater distortion in a record made of increased thickness, the amount of compressibility decreases as one increases the thickness of the interocclusal bite registration record (13% for group IIa samples of 2mm thickness > 7.6% for group IIb samples of 5mm thickness > 6.5% for group IIc samples of 10mm thickness) The mean compression undergone by samples of 2mm thickness of both Group Ia and Group IIa, the polyvinylsiloxane group and the polyether group, is similar, that is 0.26mm, as per the statistical analysis. Inferentially, polyvinylsiloxane and polyether bite registration materials, at 2mm thickness undergo the same compression in set circumstances. It is thus postulated that, polyvinylsiloxane and polyether bite registration materials at 2mm thickness resist compressive forces equally, as per the statistical analysis. This is graphically represented in Graph 3. Now since the two materials, at 2mm thickness have given similar resistance to compression, we may now safely say that polyvinylsiloxane material is preferred as it gives an economic advantage to the clinician, at the same risk of error.The mean compression undergone by samples of 5mm thickness in group IIb, that is 0.38mm, which is more by 0.08mm than by the 5mm thickness samples in group Ib, that is 0.3mm. By this we can infer that polyether material (group IIb), at 5mm thickness, undergoes more compression than polyvinylsiloxane bite registration material (group Ib) at 5mm thickness.The mean compression undergone by samples of 10mm thickness in group Ic, that is 0.42mm is lesser that the mean compression undergone by samples of 10mm thickness in group IIc, that is 0.65mm. By this we can infer that polyether material (group IIc), at 10mm thickness, undergoes more compression than polyvinylsiloxane bite registration material (group Ic) at 10mm thickness. Or we can say that, polyether bite registration material, at 10mm thickness, resists compression slightly lesser as compared to polyvinylsiloxane bite registration material at 10mm thickness. This is graphically represented in Graph 5. The most important observation was that there was significant difference in the dimensions of all the samples at various thickness obtained from both the interocclusal bite registration materials under a constant compressive load. Although numerically, interocclusal bite registration records when having the least thickness – go through the least compression; it has been observed in this study that the compressibility of polyether as well as polyvinylsiloxane bite registration records, decreases as the thickness increases. But since, for clinical applications, interocclusal records of more than 4-6mm are not utilised, elastomeric interocclusal bite registrations should be made in the least clinically possible, thickness.

It is mandatory to choose a material not only depending upon 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 of a minimal thickness; and an optimal recording material should exhibit minimal distortion during compression.

The present study was undertaken with the following aim and objective i.e. to compare the compression resistance of two different elastomeric 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, for comparison within the Group II samples was < 0.05; i.e. a statistically significant difference existed between the compression resistance of IIa and IIc samples. Whereas for the comparisons between the two groups as well as for the comparisons between the subgroups of Group I samples, the p value was found to be>0.05. Hence the null hypothesis was accepted.

Conclusion

1. Polyvinylsiloxane interocclusal bite registration material, at 10mm thickness (group Ic), shows more resistance to compression than at 5mm thickness (group Ib) and least at 2mm thickness (group Ia).
2. Polyether interocclusal bite registration material, at 10mm thickness (group IIc), shows more resistance to compression than at 5mm thickness (group IIb) and least at 2mm thickness (group IIa).
3. The resistance to compression for both the materials, at 2mm thickness (groups Ia&IIa) was found to be similar. The resistance to compression at 5mm thickness, was found to be more with the polyvinylsiloxane bite registration material (group Ib) as compared to the polyether bite registration material (group IIb). The resistance to compression at 10mm thickness, was found to be more with the polyvinylsiloxane bite registration material (group Ic) as compared to the polyether bite registration material (group IIc).

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