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# Comparative Evaluation Of Tear Strength And Compressive Resistance Of Three Commercially Available Bite Registration Materials: An In Vitro Study

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**ABSTRACT**

**BACKGROUND:**

An interocclusal record is a precise recording of a maxillomandibular position . Accurate mounting can lead to restorations that require minimal occlusal modifications intraorally, thus reducing the chairside time. The impression materials are altered by the addition of plasticizers and catalysts in order to transform them into interocclusal recording medium.

**AIM:** To evaluate the tear strength and compressive resistance of three commercially available bite registration materials.

**MATERIALS AND METHODS:** The present study was conducted to evaluate the tear strength and compressive resistance of three bite registration materials namely Polyether, Bis-acrylate and Thermoplastic resin. A total of 48 samples, including 16 samples for each bite registration material,

were prepared. 8 samples were used in each of the three subgroups of samples for evaluation. The obtained data was subjected to statistical analysis using SPSS 22.0 software. The One way ANOVA test was used to compare study parameters among the groups. Tukey's post-hoc test was used for multiple comparison between the groups.

**RESULTS:** Statistically, Bis-acrylates and Thermoplastic groups have similar tear strength but have better tear strength than the Polyether group. Bis-acrylates and Polyether Groups had similar compressive resistance but had better compressive resistance than the Thermoplastic Group.

**CONCLUSION:** Thermoplastic resin was examined to have the highest tear strength followed by Bis-acrylate and Polyether. Polyether was found to have the highest compressive resistance followed by Bis-acrylate and Thermoplastic resin. Bis-acyrlate showed median values for tear strength and compressive resistance. Therefore choice of interocclusal registration material can be decided by the clinician based on case specificity and considering the advantages and drawbacks of each material.

**KEY WORDS :**

Polyether Bite Registration material, Bis-acrylate Bite Registration material, Thermoplastic resin, BD Impress, tear strength and compressive resistance

## INTRODUCTION

In order to properly diagnose and treat a patient for prosthetic rehabilitation, it is essential to document and effectively represent the maxillomandibular relationship using diagnostic and master casts and transfer it to the articulator[1]. An interocclusal record is a precise recording of a maxillomandibular position [2]. Accurate mounting can lead to restorations that require minimal occlusal modifications intraorally, thus reducing the chairside time[1]. The elastomeric compounds used as bite registration materials resemble the impression materials[8]. The impression materials are altered by the addition of plasticizers and catalysts in order to transform them into interocclusal recording medium. For both edentulous and dentulous individuals, the interocclusal bite registration material must be stable, strong, and able to repeat the same maxillomandibular relation in the articulator.

Recording an accurate bite registration benefits the temporomandibular joint and other supporting structures. The primary goal of these records is to replicate the specific details such as cuspal shape, endure compressive stresses, preserve dimensional stability, have adequate wettability and possess qualities that make handling them simple. Material for interocclusal registration is mostly specified under some scenarios such as complete edentulism, worn-out states, full mouth rehabilitations, and distal extension-partially edentulous where reference stops are not present. Any discrepancy in the interocclusal records leads to final prosthesis occlusal errors. In order to withstand deformation and prevent breakage, interocclusal recordings are supposed to have a minimum thickness of 3 to 4 mm, but due to the shorter inter-ridge distance this thickness cannot be offered[5]. In these kinds of clinical situations, the requirement for interocclusal recording material with sufficient strength and dimensional stability will be crucial.

Finding an appropriate material to solve this challenge is therefore necessary. For a long time,

maxillomandibular relations have been recorded using plaster, modelling clay, waxes, acrylic resin, and zinc oxide-eugenol paste. The introduction of polyether, bisacrylic and polyvinylsiloxane interocclusal recording media has made clinicians to think about the choice as to which material to be used. They are popular because of their resistance to compression, surface hardness, high tear strength, dimensional accuracy and stability[7]. It's not always possible to articulate maxillary-mandibular casts immediately after the clinical procedure. Therefore, in those circumstances, the interocclusal bite registration records must be dimensionally stable[5].

Moreover, before being used to mount the casts in the articulator, these records must be dimensionally stable for a pre-determined amount of time. A compressive force is commonly exerted on the interocclusal recording material during the articulation procedure. 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[3]. Similarly, the tear strength can likewise record the bite with precision and accuracy[4]. A clinician should be able to select the best material from the market by understanding its composition, application methods, characteristics, and other aspects that affect the interocclusal recording material's ability to yield consistent results. The accuracy, viscosity, thermal conductivity, setting characteristics, detail reproduction, elasticity compressive resistance and dimensional stability of various interocclusal recording materials have all been the subject of several investigations during the last few years. The precision of getting good results has been improving with new materials. In 2018, a thermoplastic resin material (BD IMPRESS) has been suggested for usage in interocclusal bite registration material. This material is easy to manipulate and can be reshaped as many times in hot water until it takes to achieve the perfect impression. However, there has been minimal literature evidence regarding its properties for application as a bite registration material.

Therefore the present study was undertaken for comparative evaluation of tear strength and compressive resistance of two normally used commercially available bite registration materials such as Bis-acrylic ( DMG LuxaBite™ Bisacryl Registration Material USA) and Polyether (3M™ ESPE™ RAMITEC™, USA) to the newly introduced reusable Thermoplastic resin ( BD Impress Merz Dental, GERMANY). The null hypothesis was there is no difference in the tear strength and compressive resistance of the three bite registration materials.

## MATERIALS AND METHODS

The present study was conducted to evaluate the tear strength and compressive resistance of three bite registration materials.

### MATERIALS USED:

1. Polyether Bite Registration material (3M™ ESPE™ RAMITEC™, USA)
2. Bis-acrylate Bite Registration material (LuxaBite™ Bisacryl Registration Material, USA)
3. Thermoplastic resin (BD Impress Merz Dental, GERMANY)

4. Custom made dumbbell shaped metal alloy jig.
5. Custom made hollow cylindrical jig of diameter 10mm and height of 5mm.
6. Custom made mould in commonly used dental flask.
7. Universal testing machine (CIPET, INDIA).

**METHODOLOGY:**

A total of 48 samples, including 16 samples for each bite registration material, were prepared. 8 samples (n=8) were used in each of the three subgroups of samples for each bite registration material to assess the tear strength and compressive resistance, respectively.

GROUP I: specimen of Polyether bite registration material

n=16

IA (n=8): Dumbbell shaped to check the tear strength. (Fig 3)

IB (n=8): Cylindrical shaped to check compressive resistance. (Fig 4)

GROUP II: specimen of bis-acrylate bite registration material

n=16

IIA (n=8): Dumbbell shaped to check the tear strength. (Fig 3)

IIB (n=8): Cylindrical shaped to check compressive resistance. (Fig 4)

GROUP III: specimen of Thermoplastic resin bite registration material

n=16

IIIA (n=8): Dumbbell shaped to check the tear strength. (Fig 3)

IIIB (n=8): Cylindrical shaped to check compressive resistance. (Fig 4)

**Preparing samples for Tear strength (TS) evaluation**

According to ASTM (American Society for Testing and Materials) 638, dumbbell-shaped Aluminium metal jigs (Fig 1) were made with a 2mm thickness, 80mm length, 5mm of peripheral width, and 3mm of central width. The dental flask containing dental stone was then filled with the jigs to create mold. According to the manufacturer's directions, the chosen bite registration components were mixed and then put into the mold. Care was taken to prevent air entrapment into the prepared samples. After that, the set material was taken out and put in a container for future testing.

**Preparation of test specimens for compressive resistance (CR) evaluation**

A cylindrical hollow tube (Fig 2) of internal diameter 10mm and length of 5mm was made. For simple sample retrieval following setting, both sides were left open and lubricant was coated on each die. For even pressure distribution, the materials were combined and packed into the mold, and covered with two flat metallic plates for even pressure distribution. Then the set material was taken out and put in a container for future testing.

**Evaluation of tear strength**

The universal testing machine was used to apply a tensile stress to the dumbbell-shaped specimens from each material group at a crosshead speed of 5mm/min. The load at which the tear occurred was noted. The following equations were used to compute tear strength:

TS (MPa) = F/A.

Where A is the cross-sectional area of undisturbed samples ($mm^2$) and F is the rupture force in newtons(N).

**Evaluation of Compressive resistance**

Using a Universal Testing Machine, the cylindrical specimens (n=8) from each material group were put through the Compressive Resistance test. The force was increased steadily until the specimen began to distort. The instrument recorded the compressive resistance.

**STATISTICAL ANALYSIS**

The obtained data was subjected to statistical analysis using SPSS 22.0 software (Statistical Package for the Social Sciences, IBM Corp., Armonk). The One way ANOVA test was used to compare study parameters among the groups. Tukey's post-hoc test was used for multiple comparison between the groups.

**RESULTS**

The present study was conducted to comparatively evaluate the tear strength and compressive resistance of three commercially available bite registration materials by using a universal testing machine.

It was found that the Thermoplastic Group had the highest tear strength followed by the Bis-acrylates Group and the Polyether Group had the lowest tear strength (Graph 1). However, Table 1 shows that there is a difference in mean values between the groups and it was found to be statistically significant (P = 0.001). A post hoc multiple comparisons (Tukeys) test revealed a significant difference between Bis-acrylates and Polyether Groups (P = 0.025) and the difference between Polyether and the Thermoplastic Groups (P = 0.001). There was no statistically significant difference between Bis-acrylates and Thermoplastic groups (P = 0.057) (Table 1.1 ). In other words, statistically, Bis-acrylates and Thermoplastic groups have similar tear strength but have better tear strength than the Polyether group.

It was found that the Polyether Group had the highest compressive resistance followed by the Bis-acrylate Group and the Thermoplastic Group had the lowest compressive resistance (Graph 2). However, Table 2 shows that there is a difference in mean values between the groups and it was found to be statistically significant (P = 0.001). A post hoc multiple comparisons (Tukeys) test revealed a significant difference between the Bis-acrylate Group and Thermoplastic Group (P = 0.001) and the difference between Polyether Group and Thermoplastic Group (P = 0.001) (Table 2.1). In other words, statistically, Bis-acrylates and Polyether Groups had similar compressive resistance but had better compressive resistance than the Thermoplastic Group.

**DISCUSSION**

The present *in vitro* study evaluated the tear strength and compressive resistance of three commercially available bite registration materials (thermoplastic resin, polyether and bis-acrylic). Two materials (Polyether and Bis-acrylic) commonly used in the clinical scenario were compared with a

new material (thermoplastic resin) which was claimed to have superior properties.

Oral rehabilitation involves a series of sequential steps that must be followed very judiciously to obtain the desired results[11]. The success of any prosthetic rehabilitation depends on various aspects related to the precise mounting of casts in the articulator. An accurate transfer is required for occlusal quality and the essential fabrication of a prosthetic restoration[12]. The degree of accuracy of the record between the articulator and the patient depends on the type of articulator, biologic factors and the recording material. Cases where the number of teeth present is satisfactory and will provide cast stability, manual articulation can be done. On the other hand, when large edentulous spaces are present, specifically in posterior edentulous scenarios, mounting of the cast is considerably more complex. It increases the need for accurate transfer of the interocclusal relationship and vertical dimension. The three dimensional maxillomandibular relationship depends not only on the facebow and articulator but also on the recording medium used to record the details while mounting[6]. There are various methods of recording maxillomandibular relationships namely, graphic, functional, cephalometric and direct interocclusal recordings. Direct interocclusal records are most commonly used to record maxillomandibular relationships because of their simplicity.

A recording medium is necessary to register the patient's inter-arch relationship. These materials are basically impression materials modified to give better handling characteristics. Apart from the operator's clinical ability and the technique followed, the chosen material can critically affect the accuracy of the interocclusal registration. Some of the important requirement of interocclusal materials include limited initial resistance to closure in order to avoid the displacement of periodontally compromised teeth or of the mandible during record making, dimensional stability after setting, resistance to compression after polymerization, ease of manipulation, biocompatibility, accurate recording of the incisal or occlusal surfaces of the teeth and ease of verification.

One of the most desirable characteristics of the interocclusal registration material is resistance to compression after polymerization. Maxillomandibular relationships that were registered correctly in the patient can be erroneously transferred in the mounting procedures because of the compressibility of the materials. If a material is compressible, it can get distorted by faulty manipulation. There is no material, however, that has all the properties as "classical" interocclusal registration medium. The various drawbacks include distortion, compression and tearing in commonly used materials like dental waxes, dental plaster and zinc-oxide eugenol. Elastomeric materials have grown in popularity in prosthodontics[15]. But the commonly used polyvinyl siloxane undergoes shrinkage due to the loss of byproducts, leading to questionable dimensional stability. The flowability and flexibility of polyether is very less, making it a stiff material that is easily subjected to breakage. Moreover these materials require proper operator skills and patient cooperation. In recent times, a reusable biocompatible thermoplastic impression material [BD Impress] has gained popularity to be used as a bite registration material for their ability to resist the dimensional changes. The bite registeration material should have high compressive resistance to prevent distortion caused by handling or processing. In the present study, three bite registration materials viz. Luxabite (Bis-acrylate), Ramitec (Polyether) and BD

Impress (Thermoplastic resin) were subjected to increasing compressive load. On comparison of mean compressive strength between different bite registration material, Polyether Group was found to be highest followed by Bis-acrylate Group and Thermoplastic Group. Statistically, Bis-acrylates and Polyether Groups had similar compressive strength but had better compressive strength than the Thermoplastic Group. Polyether showed greater resistance to compression than Bis-acrylate and BD Impress. The probable reason for the greater compressive resistance of Polyether could be its low dimensional changes compared to other bite registration materials[14]. This is similar to study done by Koppolu SK et al wherein they evaluated the compressive resistance of Thermoplastic resin and Bis-acrylic found that bis- acrylic showed high resistance to compression over thermoplastic resin[10]. In addition a similar study by Hariprasad A et al on evaluation of the tear strength and compressive resistance of Bis-acrylate and Polyether, reported that Bis-Acrylate exhibited the greatest tear strength than Polyether and more compressive resistance was observed in Polyether than Bis-Acrylate[9].

Bite registration materials should resist tearing when tensile stresses are applied during removal of the record and also during mounted cast separation. They are most susceptible to tearing in the interproximal areas. Tear in the bite record causes defects, which will affect the accuracy of the final restoration. Additionally, some record material remnants remaining in the interdental area may precipitate localized inflammation. Therefore, it is necessary for impression materials to have maximum tear strength at the time of removal[13]. In the present study three bite registration materials viz. Luxabite (Bis-acrylate), Ramitec (polyether) and BD impress (Thermoplastic resin) were subjected to increasing tensile load. On comparison of mean tear strength between different bite registration material, Thermoplastic Group was found to be highest followed by Bis-acrylate Group and polyether Group. The difference in mean values between the groups was found to be statistically significant. Our study showed that Bis-acrylates and Thermoplastic groups had similar tear strength but had better tear strength than the Polyether group. The Thermoplastic Group had the highest tear strength followed by the Bis-acrylates and Polyether Group. The reason for the higher tear strength of Bis-acrylate is possibly due to the highly dense polymer structure which permits the material to resist tensional force maximum[9]. Therefore the clinicians should choose interocclusal registration materials that display the least possible elastic or plastic distortion due to compression from a load. 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, by the technician or other means used to stabilize the casts during the mounting procedure. In the presence of undercuts and periodontally compromised cases the clinicians could consider using BD impress as their material of choice.

The limitation of this in vitro study is that the results may differ when applied to in vivo use of tested material and its behavior. Also, these Bite registration materials were not made under ideal clinical conditions such as the presence of steep cuspal heights, deep undercuts, soft tissues interferences, decreased mouth opening, blood and saliva which could have affected the accuracy of the bite registrations. Further studies can be conducted clinically to assess the values of tear strength and compressive resistance that could occur in a clinical situations. The future direction of this study

in a clinical situations could lead to use of BD Impress as a bite registration material which could be reusable, consuming less time, economical and ease of manipulation than other commercially available bite registration materials.

## CONCLUSION

Thermoplastic resin was examined to have the highest tear strength followed by Bis-acrylate and Polyether. Polyether was found to have the highest compressive resistance followed by Bis-acrylate and Thermoplastic resin. Bis-acyrlate showed median values for tear strength and compressive resistance. Therefore choice of interocclusal registration material can be decided by the clinician based on case specificity and considering the advantages and drawbacks of each material.

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LEGENDS AND FIGURES:

(Fig 1) Dumbbell-shaped Aluminium metal jigs

(Fig 2) A cylindrical hollow tube

(Fig 3) Dumbbell shaped – Bis acrylate, polyether and thermoplastic resin

(Fig 4) Cylindrical shaped – Bis acrylate, polyether and thermoplastic resin

**Graph 1: Mean tear strength between different bite registration materials**

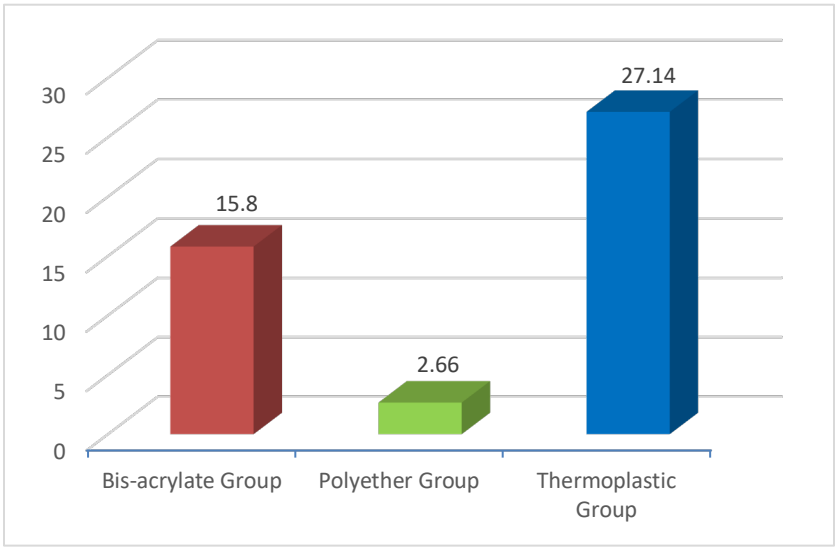


**Table 1: Comparison of mean tear strength between different bite registration material**

| | N | Mean | SD | F | P value |
|---|---|---|---|---|---|
| Bis-acrylate Group | 8 | 15.8 | 3.9 | 14.075 | P = 0.001** |
| Polyether Group | 8 | 2.66 | 2.5 | | |
| Thermoplastic Group | 8 | 27.14 | 15.2 | | |

N-number; SD-standard deviation
**statistically significant at P < 0.05 using One way ANOVA

**Table 1.1: Multiple comparison tests between the groups**

| | | MD | P value |
|---|---|---|---|
| Bis-acrylate Group | Polyether Group | 13.14 | P = 0.025* |
| | Thermoplastic Group | -11.33 | P = 0.057 |
| Polyether Group | Thermoplastic Group | -24.48 | P = 0.001** |

MD-mean difference;
**statistically significant at P < 0.05 using Tukey's post hoc test

**Graph 2: Mean compressive resistance between different bite registration materials**

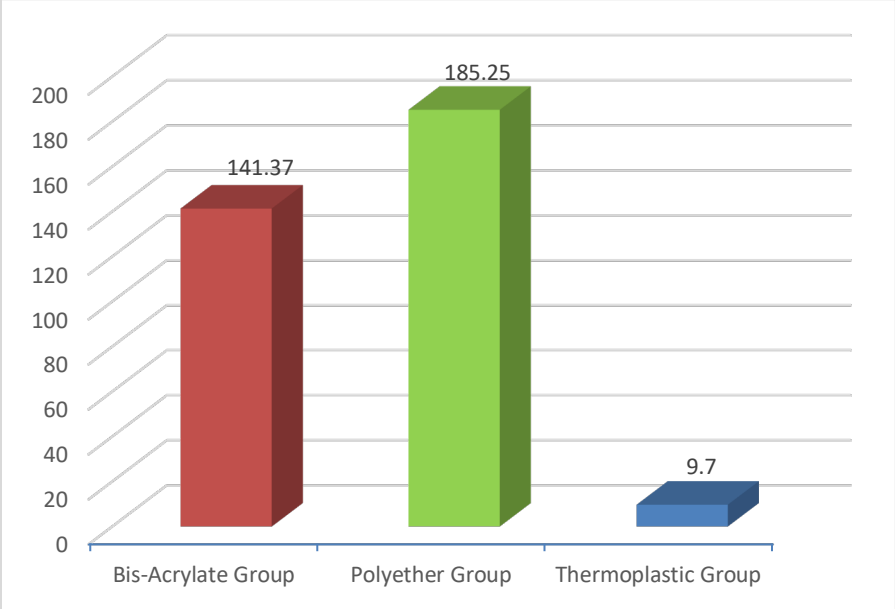


**Table 2: Comparison of mean compressive resistance between different bite registration material**

| | N | Mean | SD | F | P value |
|---|---|---|---|---|---|
| Bis-acrylate Group | 8 | 141.37 | 60.56 | 18.53 | P = 0.001** |
| Polyether Group | 8 | 185.25 | 84.4 | | |
| Thermoplastic Group | 8 | 9.7 | 1.46 | | |

N-number; SD-standard deviation
**statistically significant at P < 0.05 using One way ANOVA

**Table 2.1: Multiple comparison test between the groups**

| | | MD | P value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Bis-acrylate Group | Polyether Group | -43.8 | P = 0.33 |
| | Thermoplastic Group | 131.62 | P = 0.001** |
| Polyether Group | Thermoplastic Group | 175.5 | P = 0.001** |

MD-mean difference;

**statistically significant at $P < 0.05$ using Tukey's post hoc test