THE EFFECT OF VARIOUS SPLINTING MATERIALS ON THE ACCURACY OF OPEN TRAY IMPLANT IMPRESSIONS- AN INVITRO COMPARATIVE STUDY

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INTRODUCTION

Osseointegrated implants have provided alternative treatment solutions to conventional prosthesis for patients who lost their teeth and have achieved predictable long-term results[9, 14]. An accurate and passively fitting prosthesis as well as error-free surgical procedure is mandatory for long term implant success[29].

The fabrication of superstructures with a passive fit is the major objective of making an implant-supported prosthesis . In order to obtain a passive fit prosthesis the impression procedure needs to be accurate. An accurate impression will help in the success of the implant prosthesis.

This concept of passive adaptation has been defined as a strictly tolerated metal to metal interface between an implant superstructure and the implant abutments. Failure to produce a passive fit can result in the generation of stresses at the implant abutment interface, which may lead to complications and mechanical failure[5].

The uneven distribution of occlusal load and torquing put stress on the implant superstructure which will lead to marginal bone loss and failure of implants. This leads to mechanical problems like loosening of screws and fatigue fractures of implant components[66].

Hence to connect a multi-unit implant prosthesis with a passive fit in clinical situation, will be a challenge as there are many potential inaccuracies with current materials. This includes dimensional changes in impression materials, investment materials, wax and acrylic pattern, expansion of gypsum die product and volumetric shrinkage of metal casting on solidification[56].

Among these variables, the precise transfer of the spatial relationships of implants from the mouth to the master cast with an impression is the first and critical step to ensure passive fit of implant framework. Therefore, clinicians should strive for improving the transfer accuracy of the impression analog[31]. Various techniques have been suggested to achieve an accurate master cast.

Anatomic constraints sometimes make it necessary to surgically position implants at an angle that are not optimal for prosthetic restorations. Similarly, many researchers have evaluated the accuracy of implant impression materials and better results have been obtained with polyether (PE) and polyvinylsiloxane (PVS) [17, 20] in comparison to condensation silicone, polysulfide, irreversible hydrocolloid, and plaster materials. Similar data also exist in terms of splinting, angulation, or different impression materials, respectively.

There are two main techniques for dental implants impression, the direct (open tray) and indirect (closed tray) impression technique. In the open tray technique, the impression coping is incorporated in the impression and is removed from the mouth, together with the set impression. In the closed tray technique, the impression coping is retained in the mouth when the set impression is removed[7].

To ensure maximum accuracy, some authors emphasized the importance of splinting impression copings together intra-orally before making an impression. Various materials such as acrylic resin, dental plaster, bite registration silicone, and polyether (PE) have been used as splinting materials with varying degrees of accuracy[19].

With regard to splinting the impression copings, there are many controversies that exist since Branemark et al emphasized the importance of splinting impression copings together before registration of multiple implant impression[9]. The common practice of joining the direct transfer copings with acrylic resin is an attempt to stabilize the copings against rotation during fixture or abutment analog fastening, control the relationship between implants in a rigid fashion However, various literature studies showed no significant differences between the values obtained with acrylic resin splinted versus unsplinted groups in impression technique[23].

Studies involved multiple variables of techniques and materials, the consistent findings were one of the distortions resulting from the transfer manipulations. The same objective could be partially accomplished with a rigid impression material or an elastic material with a low flexibility, both of which do not introduce the polymerization shrinkage variables inherent in the use of acrylic resin.

Vigolo et al[49] suggested that the impression technique involving square impression copings which were previously airborne particle abraded and adhesive coated and splinted together with autopolymerizing acrylic resin could improve accuracy of the master cast than non-modified squared transfer copings which were not splinted.

Cabral Leonardo and Carlos[13] compared four impression techniques involving indirect impression technique with tapered transfer copings, direct impression technique with unsplinted squared transfer copings, direct impression technique with squared transfer copings splinted with acrylic resin, and direct impression technique with squared transfer copings with acrylic resin splints sectioned 17 minutes after setting and welded with the same resin and concluded that the direct impression technique with squared transfer copings with acrylic resin splints sectioned and welded after setting had better results than the other techniques studied.

Among the direct impression techniques, both splinting and non-splinting have been advocated for accurate impressions[23]. Splinting with impression plaster, resin or bite registration material are recommended for maintaining a more accurate inter implant relationship although the accuracy of the techniques in yielding accurate casts is controversial[43]. In-order to have rigid and dimensionally stable material a newer material BisGMA has been used to splint the impression copings.

The purpose of this in vitro study was to evaluate the effect of dimensional stability of conventionally used and advanced splinting materials on the accuracy of master casts.

AIM AND OBJECTIVE

AIM:

The study is aimed at evaluating the accuracy of the master cast using open tray impression technique with conventional and novel splinting materials.

OBJECTIVES:

1. To determine the linear inter-implant distances in the master cast obtained by splinting the impression copings using auto-polymerising acrylic resin (pattern resin).
2. To determine the linear inter-implant distances in the master cast obtained by splinting the impression copings using Pro temp (bis-GMA) syringable temporization material.
3. To determine the linear inter-implant distances in the master cast obtained by splinting the impression copings using polyvinylsiloxane (putty consistency).
4. To compare the linear inter-implant distances in the master cast obtained by splinting the impression copings using auto-polymerizing acrylic resin (pattern resin), Pro temp (bis-GMA) syringable temporization material and polyvinylsiloxane (putty consistency).

The null hypothesis $H_0$1of the study assumes that there no significant difference in the linear inter-implant distances in the master cast obtained by splinting with auto-polymerizing acrylic resin (pattern resin), Pro-temp (bis-GMA) syringable temporization material and polyvinylsiloxane (putty consistency).

The null hypothesis $H_0$2 of the study assumes that there is a significant difference in the linear inter-implant distances in the master cast obtained by splinting with auto-polymerizing acrylic resin (pattern resin), Pro-temp (bis-GMA) syringable temporization material and polyvinylsiloxane (putty consistency).

REVIEW OF LITERATURE

MARK SPECTOR et al in 1990[42] did a study for evaluating the impression techniques for Osseointegrated implants. They developed an experimental model to test the accuracy of three impression techniques and the components used to make the transfer records. In technique I a pin retained transfer coping united with autopolymerizing resin and the impression was made with polysulfide material. In technique II a polyvinyl siloxane impression was made in a stock tray over hydrocolloid transfer copings. In technique III a condensation silicone impression was made in a stock tray over hydrocolloid transfer copings. They described that there was no significant differences between the three methods and further concluded that distortions with autopolymerizing acrylic resin increase proportionally to the mass of the resin involved and distortions with polyvinyl siloxane and condensation silicone may be due to the difficulty in accurate orientation of the impression coping and abutment replica assembly in the final impression. Sectioning of the impressions often demonstrated air entrapment and incomplete seating of the impression tray, which may have impeded accurate placement of the transfer impression coping assembly.

MARK BARRETT et al in 1993[41] did a clinical research on the accuracy of six impression implants techniques using irreversible hydrocolloid, impression plaster, polyether and polyvinyl siloxane and concluded that there was no significant difference between the techniques for the square copings but that there was a significant loss of accuracy with the tapered copings.

DAVID ASSIF et al in 1994[18] described a modified impression technique for implant-supported restoration which involves the use of a modified autopolymerizing resin custom tray to allow splinting of the impression copings directly to the tray and concluded that this method eliminates the use of the dental floss-autopolymerizing resin complex, thus decreasing resin distortion and simplifying the clinical procedures.

GAMAL BURAWI at al in 1997[23] did a study on the comparison of the dimensional accuracy of the splinted and unsplinted impression techniques for the Bone-Lock implant system. They constructed a stone model incorporating five implants. They used this model and compared the dimensional accuracy of a splinted and unsplinted impression technique. They concluded that the splinted technique exhibited more deviation from the master model than the unsplinted model. This was primarily associated with rotational discrepancies around the long axes of the implants for the splinted technique.

SOUHEIL HUSSAINI et al in 1997[61] did a study on one clinical visit for a multiple implant restoration master cast fabrication. They used an open tray and acrylic resin to splint the transfer copings. They sectioned and then rejoined the resin between the transfer copings and poured the impression by joining the analogs with impression plaster and then sectioned it and rejoined it again to stabilize the analogs and finally using dental stone to pour the impression. This technique facilitated the fabrication of the final casting by eliminating the necessary clinical time to obtain solder indexes, and thus minimizing the inconvenience to the patient.

DAVID ASSIF et al in 1999[19] did a study on the accuracy of implant impression techniques using three different splinting materials namely autopolymerizing acrylic resin, dual core acrylic resin and plaster and concluded that Impression techniques using autopolymerizing acrylic resin or impression plaster as a splinting material were significantly more accurate than dual-cure acrylic resin. Plaster is the material of choice in completely edentulous patients, since it is much easier to manipulate, less time consuming, and less expensive.

BELINDA GREGORY et al in 1999[8] described a two-step pick-up impression procedure for implant-retained overdentures. This study describes a procedure that uses 2 steps, the first is conventional border molding and impression in an individualized tray that fits over the implant abutments and the second step involves attachment of the implant impression copings to the tray and picking up the copings from the mouth. They concluded that the resultant master cast is accurate in terms of soft tissue detail, position of implant components, and relationship between soft tissue and implants.

ALVIN WEE in 2000[3] did a comparative study of impression materials for direct multi-implant impressions. In this study they evaluated the accuracy of solid implant casts fabricated from different impression materials. Two direct transfer implant impressions were made using 8 different impression materials. They concluded that the addition silicone impression material is the most suitable material for making multiple implant impressions.

HERBST et al in 2000[26] did a comparative study on four impression techniques in terms of their dimensional accuracy to reproduce implant positions on working cast using four techniques with tapered and squared type impression copings not splinted, squared impression copings splinted with autopolymerizing acrylic resin and with a lateral extension on one side not splinted. They concluded that the dimensional accuracy of all the techniques was exceptional and the observe differences can be regarded as clinically negligible. The results of this study suggest that there seems to be no clinical advantage in splinting impression transfer copings with an autopolymerizing acrylic resin.

YASUYUKI MATSUSHITA et al in 2002[68] described a modified implant impression technique which involves seating of the impression copings on the implants secured with guide pins and an opening on the buccal side of the tray near the implants is prepared along with holes in the tray to allow the head of the guide pins to protrude without contacting the tray during impression making. A light-bodied impression material is used to record the area around the remaining teeth and injection-type impression material is placed through the side opening until the material flows from the holes at the top and lingual edge of the tray. After the impression material as set, the impression containing the copings is removed. This technique forms a clear impression of the soft tissue around the implants.

NOPSARAN CHAIMATTAYOMPOL et al in 2002[46] proposed a simple method of making an implant-level impression when presented with limited space, unfavorable implant positions, or problematic implant angulations. This technique describes the use of titanium or plastic implant index copings as impression copings for an implant-level impression. Implant index copings were invented to index the hexagon position of the implant and relate the implant position to the adjacent teeth at Stage I surgery. Indexing the implant at stage I surgery enables the appropriate abutment and provisional fixed prosthesis to be inserted immediately at stage II surgery. This technique saves time and instead of waiting for soft tissue maturation 2 to 4 weeks after stage II surgery and provisional prosthesis placement even later, the patient receives a fixed provisional prosthesis on the day of stage II surgery.

PAOLO VIGOLO et al in 2003[49] did a study on the accuracy of three techniques used for multiple implant abutment impressions. Impression was made with polyether impression material using three different techniques with non-modified square impression copings, those joined together with autopolymerizing acrylic resin and others that had air borne particle-abraded and adhesive coated. They concluded that the improved accuracy of the master cast is achieved with the use of square type impression copings joined with autopolymerizing resin. The results of this study suggested that splinting implant impression copings with autopolymerizing resin or airborne particle abrading and coating the copings with impression adhesive before impression making should result in more accurate working casts. Because splinting with resin is not the preferred option when an immediate loading multiple implant impression is made, the airborne particle abrasion/impression adhesive technique should be considered.

JASON BURNS et al in 2003[27] did a study on open tray implant impressions. In this they compared the accuracy of impressions made from polycarbonate stock trays and rigid custom made trays. Within the limits of this in vitro study, rigid custom trays produced significantly more accurate impressions than the polycarbonate stock trays. The stock trays used in this study could not produce accurate impressions consistently. For analogs with a 20-mm separation, there was a difference in medians of 10mm in accuracy between the stock and custom trays. They concluded that the rigid custom trays produced significantly more accurate impressions when compared with the stock tray.

PAOLO VIGOLO et al in 2004[50] did a study on the evaluation of impression techniques for multiple internal connection implant prostheses. A reference acrylic resin model with 4 internal connection implants was fabricated. Three groups of this model were made with different impression techniques. In one group, nonmodified square impression copings were used and in the second group, the copings were joined together with autopolymerizing acrylic resin and in the third group, impressin copings previously airborne-particle abraded and coated with adhesive were used. They concluded that the accuracy of definitive cast was better when the impression copings joined together with autopolymerizing resin were used.

NICKOLAS EID in 2004[47] described an implant impression technique using a plaster index combined with silicone impression material. The flexibility of the elastomeric impression material is use to capture the undercut intraoral topography and the splinting effect of the plaster to improve the accuracy of the fit of the prosthetic components. This technique reduces the misfit of the framework and it can be used in both completely and partially edentulous patients.

ABBAS in 2005[1] described the use of wax spacers for putty-wash impression for snap-on impression copings and concluded that relief of the putty impression material must be accomplished to provide sufficient space for the wash material. Inadequate space may result in displacement of the impression assembly and a distorted impression.

KONSTANTINOS et al in 2006[35] proposed a simple impression technique for dental implants placed in close proximity or adverse angulations by the use of modified impression copings. In this technique a retained impression coping is placed on one of the implants and is secured with the accompanying screw. Using a carborandum disc the coping is cut to a point at which it no longer interferes with proper seating on the second implant and undercuts are prepared on both surfaces of the coping. The impression copings are the connected with low shrink auto-polymerizing polymethylmethacrylate resin. A custom tray made from PMMA with an access window directly above the region of implants is made for direct transfer method and the final impression is made with medium viscosity polyether.

BULENT ULUDAG et al in 2006[11] described an alternative impression technique for implant retained overdenture. According to them the resilience difference between the mucosa and implant should be considered as an important factor for making impressions of implant retained overdentures. They suggested the combined use of zinc oxide eugenol impression material with elastomeric impression material in order to record the alveolar mucosa in a functional state and the implant components accurately.

BRAIN MYUNG et al in 2006[10] used a solid bar splint for open-tray implant impression technique which involves a direct impression technique using square transfer coping splinted with a solid acrylic bar and autopolymerizing resin and concluded that the use of solid bar may decrease the amount of polymerization shrinkage due to the smaller amount of acrylic resin needed and improved efficiency.

CHEE et al in 2006[16] described impression techniques for implant dentistry. According to the author the object of impression making in implants is to accurately relate an analogue of the implant to the dental arch. In this two types of impression coping has been described. In transfer type impression coping no custom tray is required. They remain in the mouth after the removal of set impression. They are indicated in cases of limited mouth opening. In pick up type impression coping a custom tray with access to the impression coping screws is required. It is removed from the mouth together with the set impression. The impression material used is usually an elastomeric impression material and the two types most widely used shown to be the most appropriate are polyether and polyvinyl siloxane impression materials.

HEATHER CONRAD et al in 2007 did a comparative study on the accuracy of two impression techniques with angulated implants. The authors stated that accurate recording of implant locations is required in order to have a properly supported restorations and do not place additional stress on the implants. Angulated implants may result in inaccurate impressions. They made impressions of the definitive cast with angulated implants by means of open tray and closed tray technique. They concluded that the average angle errors for the closed and open tray impression techniques did not differ significantly. There was no interpretable pattern of average angle errors in terms of implant angulation and implant number. The amount of distortion was similar in all combinations of impression technique, the implant angulation, and number.

HEEJE LEE et al in 2008[25] did a study on the accuracy of implant impressions. The purposes of this study were to investigate the accuracy of published implant impression techniques and examine the clinical factors affecting implant impression accuracy. The review of abutment level or implant level internal connection implants indicated that there was greater accuracy with the splint technique than with the non-splint technique. For situations in which there were 3 or fewer implants, most studies showed no difference between the pick-up and transfer techniques, whereas for 4 or more implants showed higher accuracy with the pick-up technique. Polyether and Polyvinyl siloxane were the recommended materials for the implant impressions.

AUDREY SELECMAN et al in 2009[5] described a technique for making an implant-level impression using solid plastic, press-fit, closed-tray impression copings for implants which were less than 2 mm apart from the restorative platform and had an estimated 20-degree convergence. The distal coping was placed first to ensure access and the anterior coping was conservatively modified until it could be placed without obstruction. Removing the plastic increased the flexibility of the coping and partially eliminated its retentive features and the definitive impression was made with a medium-body, hydrophilic, addition-reaction silicone material. The implant analogs were then placed on the impression copings within the impression, and the definitive cast was poured in type IV dental stone and evaluated for prosthetic design. They concluded that solid plastic, press-fit, closed-tray impression copings can be considered an alternative to other more accurate and reliable methods when the creation of an implant-level definitive cast is challenged by implant positioning.

SANG-JIK LEE et al in 2011[57] did a study to evaluate the effect of dimensional stability of splinting material on the accuracy of master casts. Impressions were made after splintinf the square impression by different techniques namely splinting with pattern resin and sectioned, splinting resin just before the impression procedure, splinting with impression plaster and polyvinyl Siloxane bite registration material and concluded that splinting the copings with autopolymerizing resin after the compensation of polymerization shrinkage and splinting with impression plaster enhances the accuracy of master cast.

MANESH LAHORI et al in 2011[38] discussed the various impression techniques in implantology. They concluded that among the impression materials the material of choice is addition silicone as it does not leave any by-products and its good stability and polyether due to its excellent rigidity and among the impression techniques implant level open tray impressions is ideal for multi implant restorations due to its reduced chances for misfit of framework whereas abutment level closed tray impressions are ideal for single implant impressions and multiple parallel implants.

ALI GOOYA et al in 2012[2] described a modified impression technique for mandibular implant-retained overdenture. This technique uses a custom tray to make an accurate functional impression in implant-retained overdentures which will register precise implant's position because they are splinted together. It can be used in both bar and ball attachment overdentures with all kinds of implants.

NAYEREH RASHIDAN et al in 2012[45] did a comparative study on the accuracy of implant impressions with different impression coping types and shapes using polyether impression material to obtain precise definitive casts and concluded that the shape of the impression coping had more impact on impression inaccuracy than the impression technique. Understanding of the magnitude and variability of distortion when employing certain impression-making methods and impression coping shapes helps the clinician to select a better implant component and impression technique.

ERICA DORIGATTI et al in 2012[21] did a study on the comparison of the accuracy for three dental impression techniques. The accuracy of impression techniques using tapered, squared and modified square impression copings for implant-supported prostheses were compared. They concluded that tapered coping technique was technically easier to work whereas squared and modified squared coping techniques did not present any clinical advantage and did not improve the dimensional accuracy of the die stones to interpret a clinical situation.

JUNPING BERGIN et al in 2013[32] did a comparative study of photogrammetric and conventional complete-arch implant impression techniques. The objective of this study was to assess the feasibility of using a photogrammetric technique to record the location and orientation of multiple implants and to compare the results with those of a conventional complete-arch impression technique. They concluded that the photogrammetric method is capable of achieving levels of accuracy and repeatability that are comparable to the conventional impression technique and that the prototype photogrammetric method has the potential to serve as an alternative to conventional impression procedures for implant supported prosthesis impressions.

KHALED ABDULLAH et al in 2013[34] did a comparative study on the accuracy of implant impression with coded healing abutments and different implant angulations and concluded that the casts fabricated from the coded healing abutment impressions are less accurate than those fabricated from splinting the impression copings and further concluded that the accuracy of fit was not influenced by the implant angulation or position for either impression technique or by the Encode healing abutment height for the Encode impression technique.

ROXANNA et al in 2013[55] did a study on the precision of fit between implant impression coping and implant replica pairs for three implant systems. The selected implant systems represent the 3 main joint types used in implant dentistry namely the external hexagonal, internal trilobe, and internal conical. The results of the study confirmed that implant systems differ in precision of fit. Vertical precision between paired implant components is a function of joint type and the tightening force applied to the guide pin. The magnitude of vertical displacement with applied torque is greater for conical connections than for butt joint connections. The rotational freedom between paired components is unique to the implant system and is presumably related to the machining tolerances specified by the manufacturer. The angular positioning of impression copings varies among implant systems and may result in errors that will be magnified in subsequent steps of prosthesis fabrication.

BALOUCH et al in 2013[7] did a study on the comparison of dimensional accuracy between open-tray and closed-tray implant impression technique in 15° angled implants and concluded that closed tray impression method on angulated implants seems to have a significant effect in reducing the dimensional changes in comparison to open tray method which is attributed to its simplicity, accuracy of operator in implementing the technique and application of custom tray instead of prefabricated tray. Therefore closed tray method is recommended due to its more simple application and lower impression time.

SEVCAN et al in 2014[58] did a study on the digital evaluation of the accuracy of impression techniques and materials in angulated implants using two different impression techniques, splinted direct and indirect and 3 different impression materials namely polyether, vinyl polysiloxane and polyether silicone and made models simulating parallel and angulated implants. They concluded that the angulation and impression technique were found to be effective on the accuracy of implant impressions. For parallel implants, more accurate impressions were obtained with splinted direct technique and there was no significant difference between polyether and polyvinyl siloxane however polyether silicone showed higher deviations. In the presence of angulated implants the most accurate impression material was vinyl polysiloxane and the most accurate technique was splinted direct technique.

ANIL SHARMA et al in 2015[4] described contemporary impression techniques in implant prosthodontics. The aim of this article is to describe and evaluate the clinical efficacy of impression techniques in implant therapy for transferring information to the laboratory. They concluded that the selection of the impression technique and henceforth the tray depends upon the coping design. A square coping requires an open tray and the technique is therefore the direct technique. A tapered coping facilitates the use of a closed tray or indirect technique. Multiple implants bring along with them the problem of nonparallelism and the use of the indirect technique has shown to cause errors in the fitting of the framework. Bone loss and even loss of integration has been attributed to this misfit and pressure on the abutments causing them to tilt or splay apart causes the rigid implant body in the bone to be subject to stress. To increase the accuracy of the impression technique for multiple implants using the direct technique the direct transfers are splinted with acrylic. The shrinkage of acrylic however can introduce errors by causing the implants to move closer.

SUNANTHA SELVARAJ et al in 2016[63] did a study on the comparison of implant cast accuracy of multiple implant impression technique with splinting materials such as autopolymerizing acrylic resin (GC pattern resin) and Pro temp TM (bis-GMA) syringable temporization material and concluded that the master cast obtained by both the splinting material exhibits no difference from the reference model. Hence bis-GMA can be used, which is easy to handle, less time consuming, less technique sensitive, rigid, and readily available material in clinics.

RAVISHANKAR et al in 2016[51] did a study to investigate the accuracy of two kinds of impression techniques (open and closed tray) with three impression materials namely polyvinylsiloxane, polyether, vinylsiloxanether on angulated implants and two types of splinting were carried out with floss and pattern resin and the second with a plastic rod (coffee stirrer) and resin and concluded that vinylsiloxanether impression material yielded more accurate casts than those of Polyvinylsiloxane and Polyether. Splinting with floss and pattern resin was found to be more accurate than stirrer and resin.

METHODOLOGY

Table 1: Materials used in the study

S.No	Procedure	Material	Brand, Manufacturer
1.	Reference edentulous model fabrication	Rp 13mm Implants- 4 nos	Nobel Biocare Implant System Ltd, Zurich, Switzerland
		All on 4 verification jig	Nobel Biocare Implant System Ltd, Zurich, Switzerland
		Heat cure acrylic resin	DPI Heat Cure, Mumbai
2.	Fabrication of custom tray	Modelling wax	Surana, Manglore
		Light cure acrylic resin sheet	Plaque Photo, W + P Dental, Hamburg, Germany
3.	Splinting of the impression copings	All on 4 multiunit abutments 17^0 angulation-2 nos 30^0angulation-2 nos	Nobel Biocare Implant System Ltd, Zurich, Switzerland
		Open tray impression copings – 4 nos	Nobel Biocare Implant System Ltd, Zurich, Switzerland
		Dental floss	Thermoseal waxed dental floss, India
		Autopolymerizing resin (pattern resin)	GC pattern resin, Osaka, Japan
		Bis-GMA light cure temporization material	Pro-temp 4 3M ESPE, India
		Polyvinylsiloxane (putty)	3M, ESPE, Germany
4.	Final impression	Polyvinylsiloxane (putty)	3M, ESPE, Germany

	and master cast fabrication	Polyvinylsiloxane (light body)	3M, ESPE, Germany
		Polyvinylsiloxane (adhesive)	Virtual,Refill Ivoclar Vivadent
		Type IV Gypsum product	GC FUJIROCK, Prodent Europe N.V, Belgium

Table 2: Equipment used in the study

S.No	Procedure	Instrument	Brand, Manufacturer
1.	Polymerisation of the light cured pattern	Light curing unit	Sibari Sr620, SIRIO DENTAL, Italy
2.	Measurement of inter implant distances	Profile projector	HB 350, Starrett Sigma, North Yorkshire, England

Fabrication of the reference edentulous model:

A reference wax model (figure 2) with four implants Rp-10mm (Nobel Biocare Implant System Ltd, Zurich, Switzerland) was positioned in the mandibular ridge at an angulation of 0^0in the anterior region and at an angulation of 45^0in the posterior regionusing an All on 4 guide (Nobel Biocare Implant System Ltd, Zurich, Switzerland) (figure 3) and a Ney surveyor (DentsplyCeramco, Germany)(figure 4)for proper orientation.The reference model mimics a mandibular implant-supported overdenture situation[15, 36] (figure 5). Three stoppers, one in the anterior and two in the posterior region were made in the land area of the mandibular reference model to ensure the proper orientation of the impression trays. The reference model is then fabricated in heat cure acrylic resin (DPI Heat Cure, clear)(figure 6).

Fabrication of the custom tray:

Using the reference model fabricated in heat cure as a preliminary cast, a spaced primary cast was made. In order to obtain uniform spacer, 3 mm even spacer was adapted onto the reference modelusing modelling wax (Surana, Manglore)(figure 7) and the impression was made and spaced primary cast was obtained (figure 8). Twelve custom trays (four per group) with windows in the anterior region were made using light cure acrylic resin sheet (Plaque Photo, W + P Dental, Hamburg, Germany) (figure 9)of 2 mm in thickness[48]. All the custom trays are uniformly spaced and are cured in a light curing unit (SibariSr620, SIRIO DENTAL, Italy)(figure 11) using visible light of wavelength 320-550nm for a period of 5 minutes. To ensure dimensional stability of custom tray, the trays are left undisturbed for 24 hours prior to the impression making. A set of twelve custom trays were made (four per group) (figure14).

Splinting of the impression copings:

The "All on 4"multiunit abutments (Nobel Biocare Implant System Ltd, Zurich, Switzerland) of 17^0angulation in the anterior region and 30^0angulation in the posterior region are screwed to the implant body[34]. The open tray impression copings[45] (Nobel Biocare Implant System Ltd, Zurich, Switzerland) are then screwed to the multi-unit abutments at 15Ncm torque (figure15).The open tray copings were primarily splinted with dental floss[19, 57] (Thermoseal waxed dental floss, India) (figure 16, figure 17).

In Group A, Autopolymerizing resin[65] (GC pattern resin, Osaka, Japan) was mixed in the ratio of 2 g–1 ml. When the resin reached the dough stage, it was packed around the impression posts and the dental floss. The splint was allowed to polymerize for 4 minutes. The splint was sectioned in between the impression posts using a separating disc to relieve the stresses caused by polymerization shrinkage. The cut sections were joined using the same resin by applying it using brush bead method (figure 18). This was again allowed to polymerize for 4 min. The impression copings, custom tray, and the splint were coated with polyvinylsiloxane adhesive (Virtual, Refill Ivoclar Vivadent) and allowed to dry for 15 min.

In Group B, bis-GMA[57] (Pro-temp 3M ESPE, India) was used to splint the Impression copings (figure 19). The shrinkage of the material is lesser than autopolymerizing resin, so the splints were not sectioned in between the impression posts. The bis-GMA (Pro-temp 3M ESPE, India) was syringed using an automix gun (3M ESPE, India) into floss matrix between the impression post. It is allowed to set for about 7 min as per the manufacturer's instructions. Once the splinting becomes rigid, the impression copings, custom tray and the splint were all coated with polyether adhesive.

In Group C, Polyvinylsiloxane[17, 20] (Putty, 3M, ESPE, Germany) was used to splint the impression copings. The two components of polyvinylsiloxane (putty) areincorporated by hand kneading until uniform colour is achieved. This should be accomplished in 45 seconds. It was then packed around the impression posts and the dental floss and was splinted together (figure 20). The splint was allowed to set for about 5 minutes. The impression copings, custom tray, and the splint were coated with polyvinylsiloxane adhesive.

Final impression making and Master cast fabrication:

The light body polyvinylsiloxane[17, 20] was machine mixed (3M ESPE pentamix 2 Germany) and dispensed into a penta elastomer syringe (3M ESPE, Germany). It was syringed around the impression copings to avoid impression defects around the copings while the putty consistency of polyvinylsiloxane is loaded onto the custom tray. The tray was then carried onto the reference model immediately and the impressionmade. It was made sure that the tray is seated completely in the three stops that were made in the reference model to ensure complete seating and proper positioning of the custom tray. The impression was allowed to set for 6 min as per the manufacturer's recommendation (figure 21). The screws of the impression posts were unscrewed and the impression removed from the reference model.

A total of four impressions were made in each group in a similar manner. The abutment replica was fastened on to the impression copings (figure 22) and the impressions were poured using Type IV gypsum product (GC FUJIROCK, Prodent Europe N.V, Belgium). A total of 12 master cast were obtained, 4 for each group (figure 23, figure 24 and figure 25) and only one model was obtained from each impression[37].

Measurement Protocol:

A profile projector[13](HB 350, Starrett Sigma, North Yorkshire, England) was used to measure the linear distances (figure25). The pouring carrier was secured in the holder of the device and its posterior corner was set parallel to the axis movement of the machine. Each cast was placed on it and maintained in position by means of three stoppers as previously described. Such a profile projector was provided with a screen with horizontal and vertical reference lines to allow to adjust all models to identical standardized positions, in order to assure that the copings of all casts were at the same level during the measurements. The light source of the device projected a x10 magnified image of the cast to be measured onto a screen in the form of a shadow, so that the sharp edges of the projected silhouetted of the transfer copings were used as the reference points of measurement. The profile projector was provided with an integrated digitaldisplay counter and calibrated to an accuracy of +0.5um.

Four distances were measured on the control acrylic resin models and on the definitive study casts (figure 26)

(1) D1 – the distance between the external sharp edges of the projected silhouetted form of the most anterior and most posterior right impression copings (1 and 2).

(2) D2 – the distance between the internal sharp edges of the projected silhouetted form of the most anterior left and right impression copings. (2 and 3).

(3) D3 – the distance between the external sharp edges of the projected silhouetted form of the most posterior left and right impression copings. (1 and 4).

(4) D4 – the distance between the internal sharp edges of the projected silhouetted form of the most posterior left and right impression copings. (1 and 4).

Statistic Analysis: The measurements were tabulated and statistically analyzed and the results were obtained. A factorial analysis of variance using ANOVA was used for statistical analysis and P < 0.05 was considered as significant.

Fig.1.Armamentarium used for the study

Fig.2.Reference wax model

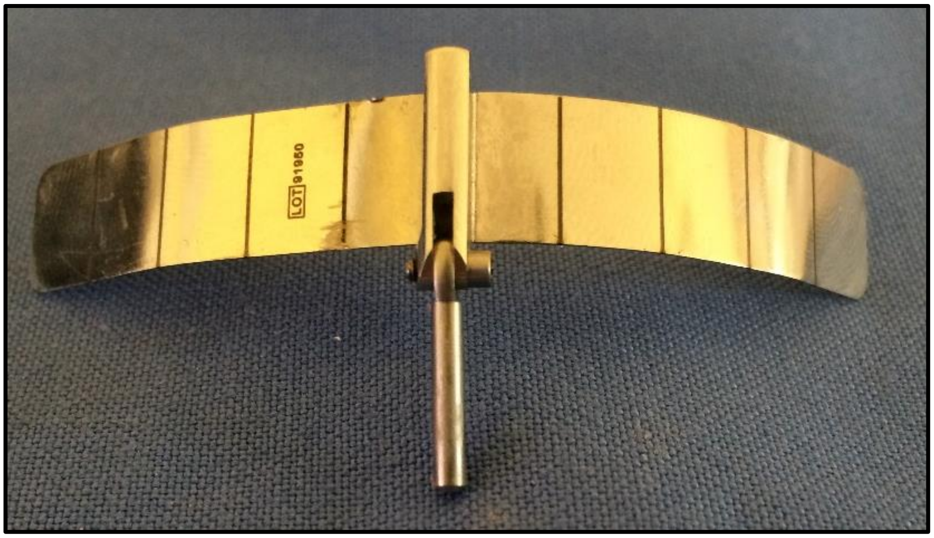


Fig.3.All on 4 guide

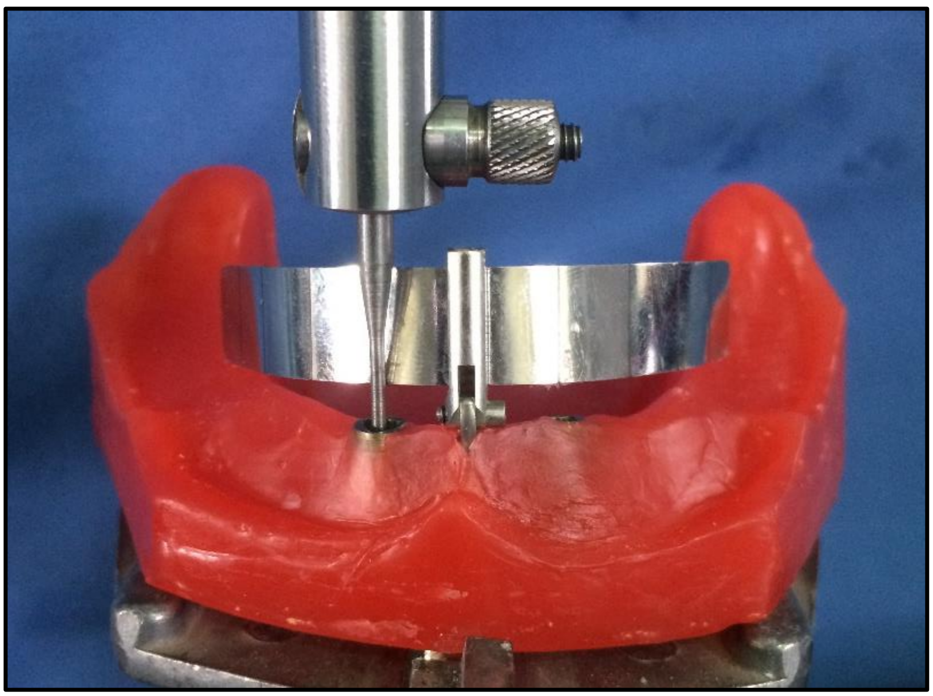


Fig.4.Implant placement using verification jig and Ney surveyor

Fig.5.Reference wax model with four Rp-10mm Implants in overdenture position

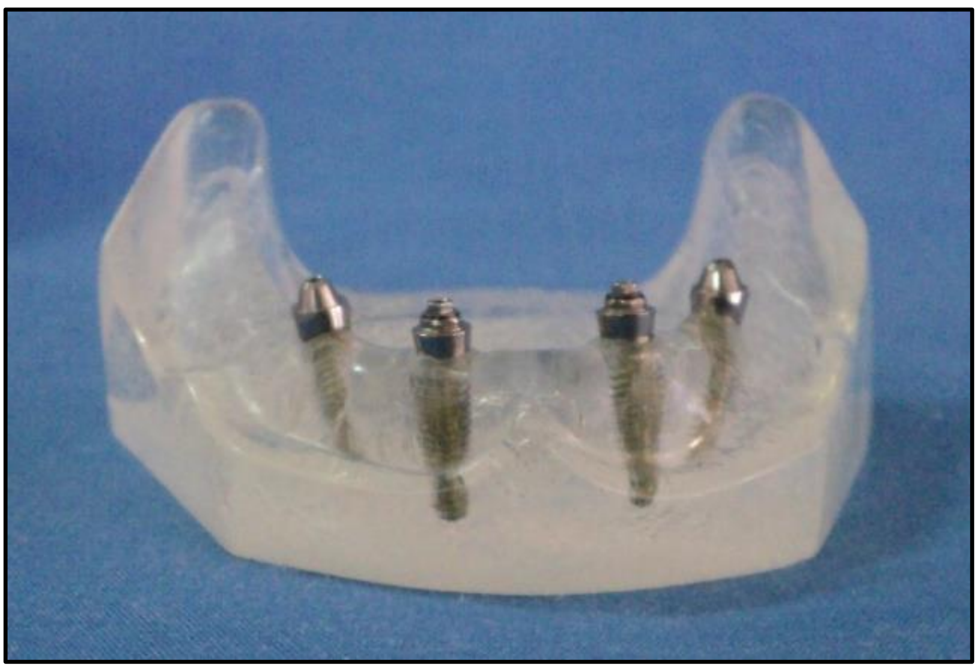


Fig.6. Fabrication of the reference model in heat cure acrylic resin

(DPI Heat Cure, clear).

Fig.7. 3mm uniform spacer adapted on the reference model

Fig.8. Spaced primary cast

Fig.9. Light cure acrylic resin sheet of 2 mm in thickness (Plaque Photo, W + P Dental, Hamburg, Germany)

Fig.10. Acrylic resin sheet adapted on the spaced cast

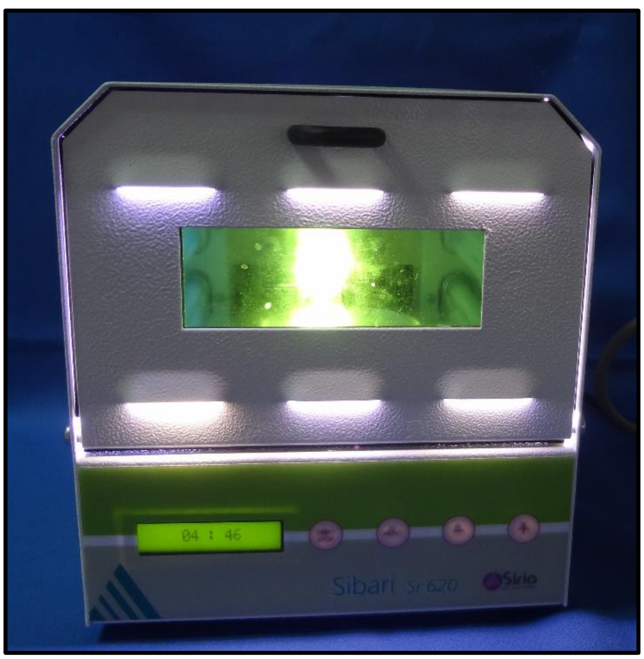


Fig.11. Light Curing Unit

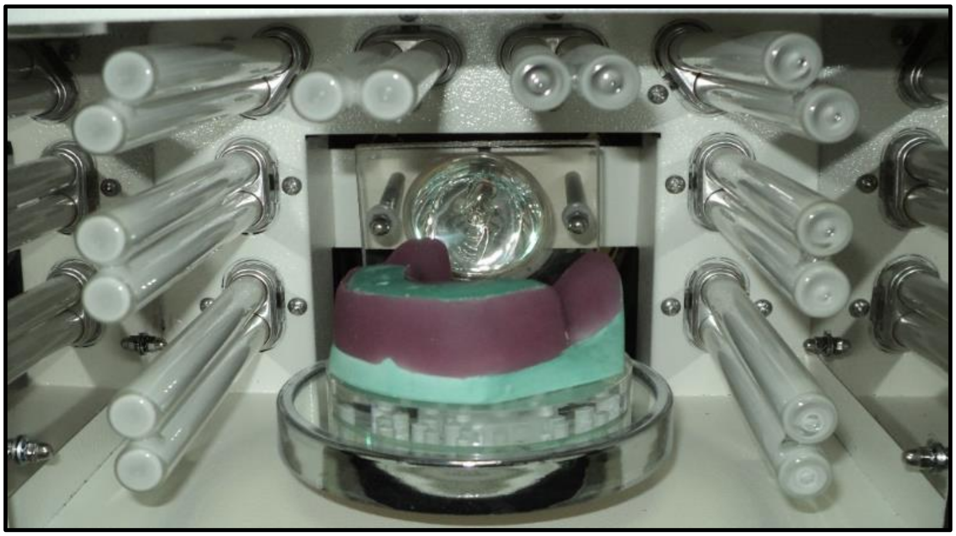


Fig.12. Curing of the acrylic resin sheet in light cure unit for a period of 5 minutes.

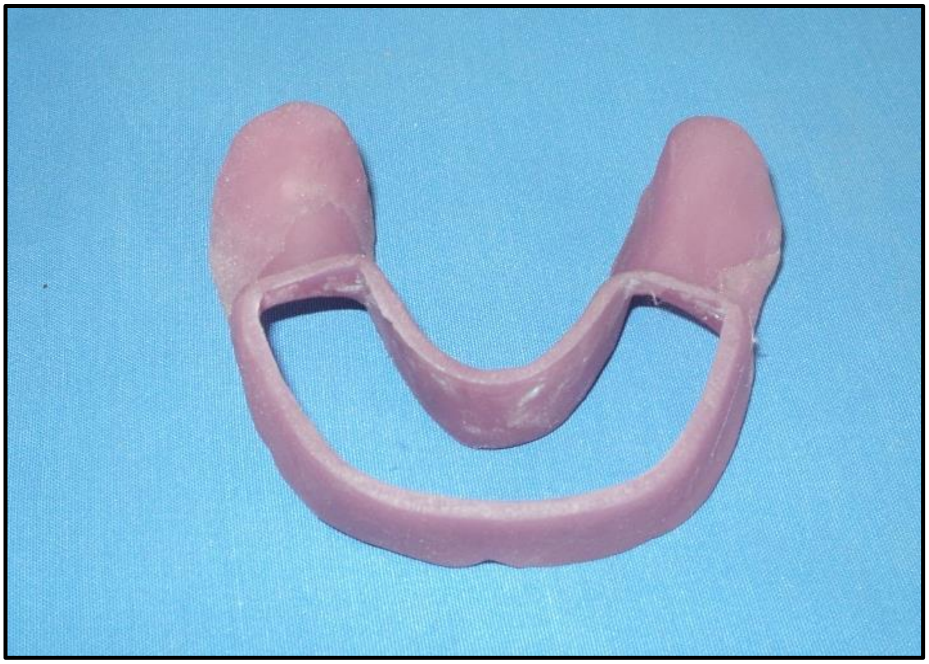


Fig.13. Custom tray fabrication with window in the anterior region

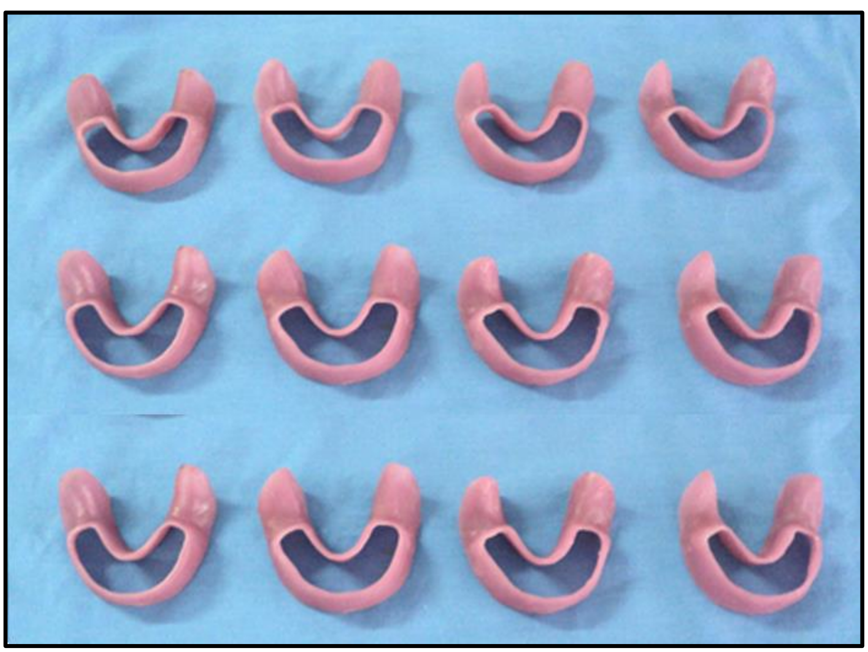


Fig.14. A set of twelve custom trays (four per group)

Fig 15. The open tray impression copings screwed to the multi-unit abutment

Fig.16. Thermoseal waxed dental floss

Fig.17. Primary splinting of the open tray impression copings with dental floss

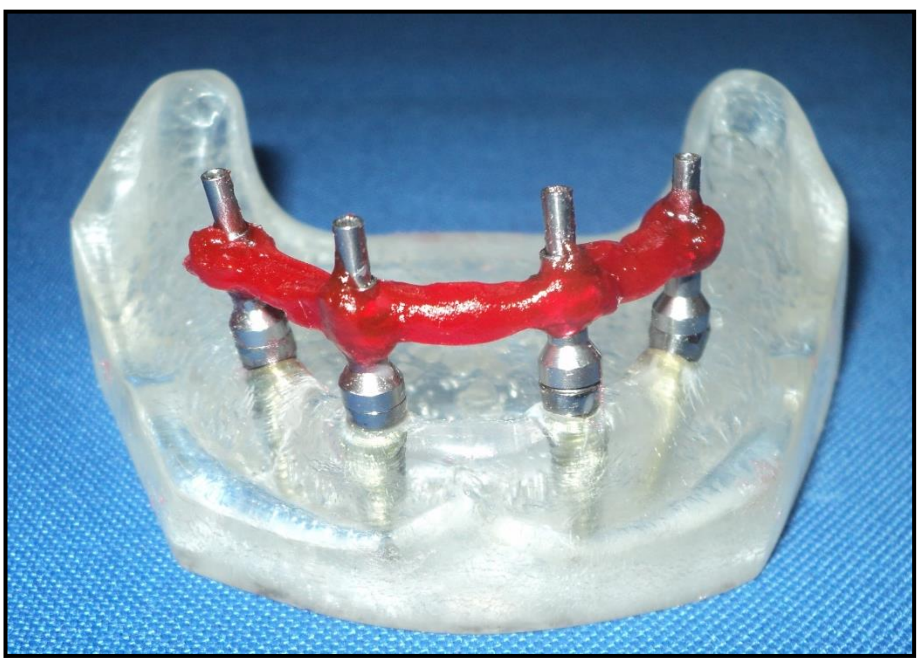


Fig.18. Splinting of the open tray impression copings with GC pattern resin

Fig.19. Splinting of the open tray impression copings with Pro-temp BisGMA

Fig.20. Splinting of the open tray impression copings with Polyvinylsiloxane in putty consistency

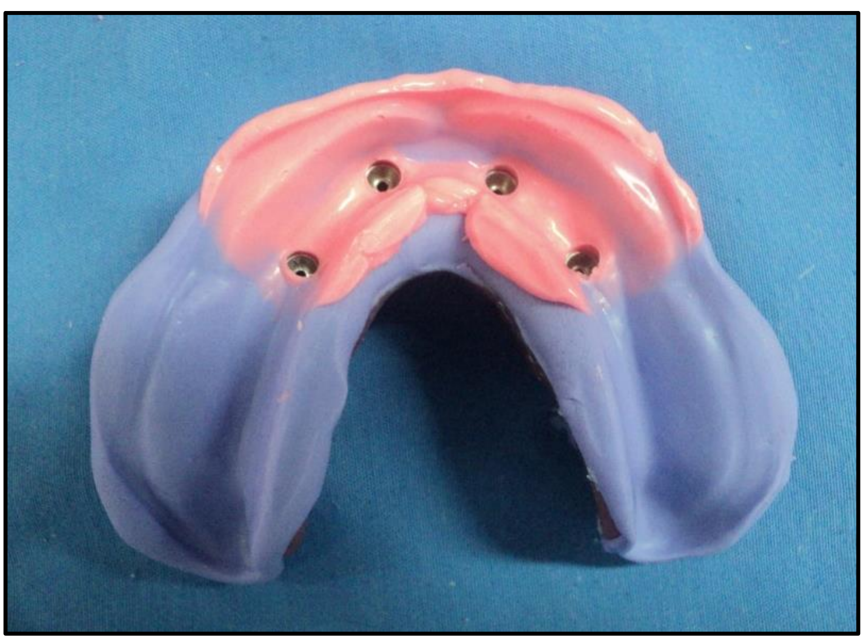


Fig.21. Final Impression made with Polyvinylsiloxane.

Fig.22. Abutment replicas fastened on to the impression copings.

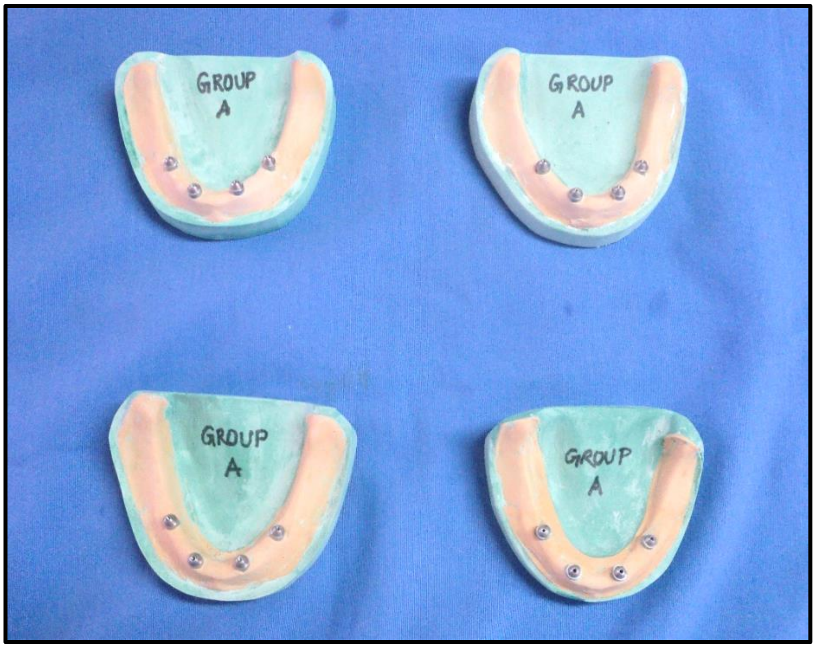


Fig.23. Master casts obtained by splinting the open tray impression copings with GC pattern resin.

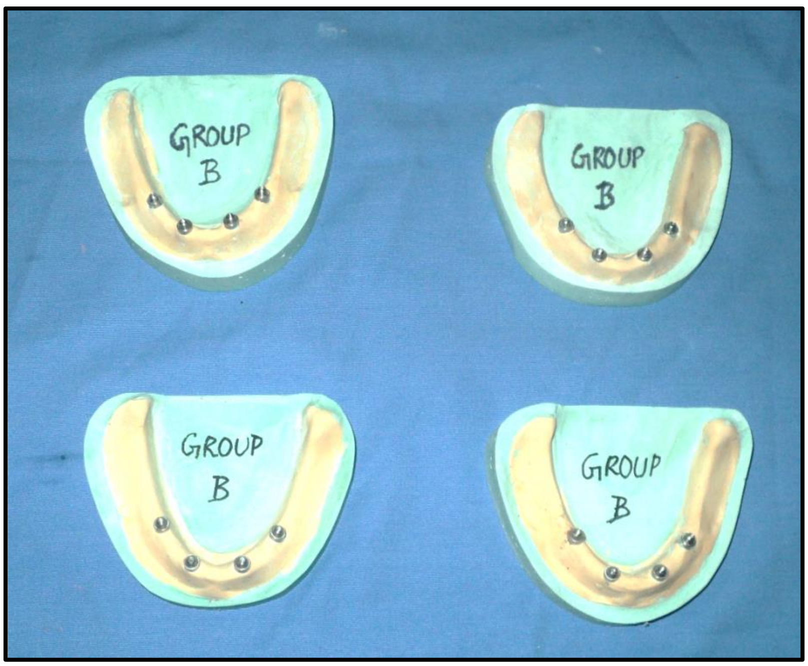


Fig.24. Master casts obtained by splinting the open tray impression copings with bis-GMA.

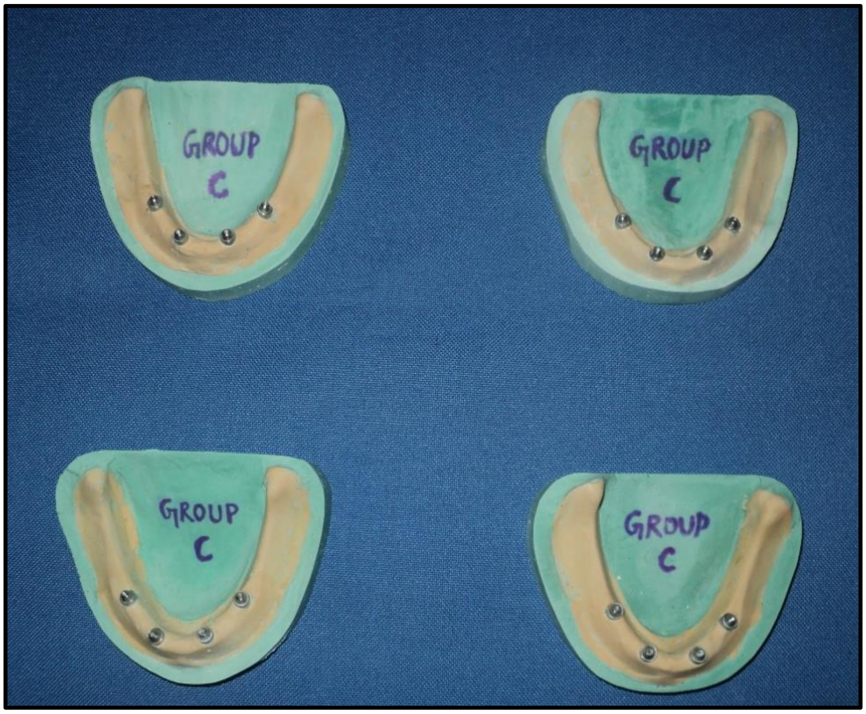


Fig.25. Master cast obtained by splinting the open tray impression copings with Polyvinylsiloxane in putty consistency.

Fig.26. Profile projector (HB 350, Starrett Sigma, North Yorkshire, England).

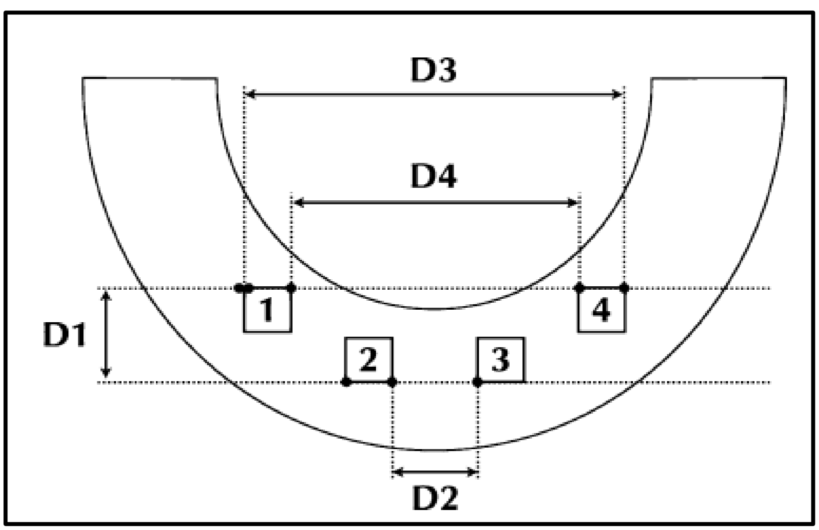


Fig.27. Distances measured on the control acrylic resin models and on the definitive study casts.

RESULTS

The linear inter-implant distances in the master cast obtained by splinting the impression copings using Auto-polymerised resin (pattern resin), Pro temp TM (bis-GMA) syringable temporization material and Polyvinylsiloxane (putty consistency) were compared with the inter-implant distance in the reference model using a profile projector and were subjected to statistical analysis.

A reference acrylic resin model (Table-1) and a total of 12 master casts was used in the study out of which, 4 master casts (Group-A, Table-2) were obtained by splinting the impression copings with Auto-polymerised pattern resin, 4 master casts (Group-B, Table-3) were obtained by splinting the impression copings with Pro temp TM (bis-GMA) syringable temporization material and 4 master casts (Group-C, Table-4) were obtained by splinting the impression copings with Polyvinylsiloxane in putty consistency. The acrylic resin modeland the master casts were assessed using a profile projector to determine the inter-implant distances.

Four distances were measured on the control acrylic resin models and on the definitive study casts

(5) D1 – the distance between the external sharp edges of the projected silhouetted form of the most anterior and most posterior right impression copings (1 and 2).

(6) D2 – the distance between the internal sharp edges of the projected silhouetted form of the most anterior left and right impression copings. (2 and 3).

(7) D3 – the distance between the external sharp edges of the projected silhouetted form of the most posterior left and right impression copings. (1 and 4).

(8) D4 – the distance between the internal sharp edges of the projected silhouetted form of the most posterior left and right impression copings. (1 and 4).

One reading each was taken for the inter-implant distances inthe reference model and for all the master casts obtained by splinting with Auto-polymerised pattern resin, Pro temp TM (bis-GMA) syringable temporization material and Polyvinylsiloxane in putty consistency.

Further, the mean of the inter-implant distances were calculated and this reading was taken as the inter-implant distance for that particular group and compared with the inter-implant distance of the reference model. The results were then subjected to statistical analysis.

Table-1

Linear inter-implant distances measured in the reference model in millimetres:

GROUP	D1 (mm)	D2 (mm)	D3 (mm)	D4 (mm)
Control model	16.71	9.84	39.32	29.72

Table-2

Linear inter-implant distances measured by splinting the impression copings with Autopolymerizing resin (GC pattern resin) in millimetres:

Group A	D1 (mm)	D2 (mm)	D3 (mm)	D4 (mm)
Model – 1	16.83	9.87	39.04	29.25
Model – 2	15.62	9.85	39.43	29.41
Model – 3	16.04	9.72	39.28	29.58
Model – 4	15.83	9.81	39.24	29.54

Table-3

Linear inter-implant distances measured by splinting the impression copings with BisGMA (Pro-temp 4 3M ESPE) in millimetres:

Group B	D1 (mm)	D2 (mm)	D3 (mm)	D4 (mm)
Model – 1	16.94	9.68	39.07	29.07
Model – 2	15.42	9.82	39.29	29.65
Model – 3	16.42	9.77	39.33	29.66
Model – 4	15.38	9.89	39.04	29.36

Table-4

Linear inter-implant distances measured by splinting the impression copings with Polyvinylsiloxane (Putty, 3M, ESPE) in millimetres:

Group C	D1 (mm)	D2 (mm)	D3 (mm)	D4 (mm)
Model – 1	16.83	9.83	38.86	29.26
Model – 2	15.10	9.73	39.01	29.41
Model – 3	16.24	9.84	39.10	29.50
Model – 4	15.93	9.69	39.05	29.45

STATISTICAL ANALYSIS:

Comparison of the inter-implant distances obtained from the master cast fabricated using three types of splinting materials with the inter-implant distances with the inter-implant distances obtained from the reference model.

Alternate Hypothesis:

$H_1$1 – There is no significant difference in the inter-implant distances in the master cast obtained by splinting with Pro temp TM (bis-GMA) syringable temporization material, autopolymerizing acrylic resin (pattern resin) and polyvinylsiloxane (putty consistency) when compared to the inter-implant distances in the reference model.

Statistical Test:

One way ANOVA followed by Post hoc analysis was done between the means of different groups to find if there was any significant difference at 0.5%.

Data was entered in spread sheet and IBM SPSS (Statistical Package for Social Sciences) Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp. was used for data analysis.

Decision Criterion:

Mean minimum, maximum and standard deviation of the inter-implant distances of the reference group and three splinting groups are listed in Table 5, 6, 7 and 8. From this data it was found that the inter-implant distances in relation to the use of autopolymerizing pattern resin showed less amount of variation from the reference model when compared to Polyvinyl siloxane (putty consistency) and BisGMA (Pro-temp 4 – syringable temporary crown material).

Table-5 Difference in the mean value between the different splinting groups from the reference model at D1 using ANOVA

Distance	Model	Number of models	Mean	SD	F Value	P Value
D1	Reference	1	16.72	.064	.613	.622
	GC pattern resin	4	16.08	.529		
	Bis-GMA (Pro-temp)	4	16.04	.769		
	Polyvinylsiloxane (putty)	4	16.03	.721		

F value and P value obtained by One way analysis of variance

*- Non significant – p value < 0.05 is significant

Table-6 Difference in the mean value between the different splinting groups from the reference model at D2 using ANOVA

Distance	Model	Number of models	Mean	SD	F Value	P Value
D2	Reference	1	9.84	.035	.496	.693
	GC pattern resin	4	9.81	.067		
	Bis-GMA (Pro-temp)	4	9.79	.088		
	Polyvinylsiloxane (putty)	4	9.77	.074		

F value and P value obtained by One way analysis of variance

*- Non significant – p value < 0.05 is significant

Table-7 Difference in the mean value between the different splinting groups from the reference model at D3 using ANOVA

Distance	Model	Number of models	Mean	SD	F Value	P Value
D3	Reference	1	39.32	.127	3.099	.076
	GC pattern resin	4	39.25	.161		
	Bis-GMA (Pro-temp)	4	39.18	.149		
	Polyvinylsiloxane (putty)	4	39.00	.103		

F value and P value obtained by One way analysis of variance

*- Non significant – p value < 0.05 is significant

Table-8 Difference in the mean value between the different splinting groups from the reference model at D4 using ANOVA

Distance	Model	Number of models	Mean	SD	F Value	P Value
D3	Reference	1	39.32	.127	3.099	.076
	GC pattern resin	4	39.25	.161		
	Bis-GMA (Pro-temp)	4	39.18	.149		
	Polyvinylsiloxane (putty)	4	39.00	.103		

F value and P value obtained by One way analysis of variance

*- Non significant – p value < 0.05 is significant

Since the difference in the mean of different groups were not statistically significant, they were subjected to Post hoc analysis using Tuskey's HSD to compare the significance between the three groups with the reference group. Table-9 revealed that there was no statistically significant difference in the inter- implant distances on the models splinted with pattern resin, bis-GMA (Pro-temp) and polyvinylsiloxane when compared to the reference model.

Table-9

Difference in the inter-implant distance within the groups using Tuskey's post hoc tests in relation to D1

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p value
D1(mm)	Reference	Self cure acrylic resin	.635	.678
		Flowable composite	.675	.637
		Elastomer	.690	.622
	Self cure acrylic resin	Control	-.635	.678
		Flowable composite	.040	1.000
		Elastomer	.055	.999
	Flowable composite	Control	-.675	.637
		Self cure acrylic resin	-.040	1.000
		Elastomer	.015	1.000
	Elastomer	Control	-.690	.622
		Self cure acrylic resin	-.055	.999
		Flowable composite	-.015	1.000

p value obtained by performing Tuskey's HSD post hoc test

*- not significant- p value <0.05 is significant

Table-10

Difference in the inter-implant distance within the groups using tukeys post hoc tests in relation to D2

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p value
D2(mm)	Reference	Self cure acrylic resin	.032	.955
		Flowable composite	.055	.824
		Elastomer	.072	.678
	Self cure acrylic resin	Control	-.032	.955
		Flowable composite	.023	.972
		Elastomer	.040	.867
	Flowable composite	Control	-.055	.824
		Self cure acrylic resin	-.023	.972
		Elastomer	.017	.986
	Elastomer	Control	-.072	.678
		Self cure acrylic resin	-.040	.867
		Flowable composite	-.017	.986

p value obtained by performing Tuskey's HSD post hoc test

*- not significant- p value <0.05 is significant

Table-11

Difference in the inter-implant distance within the groups using tukeys post hoc tests in relation to D3

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p value
D3(mm)	Reference	Self cure acrylic resin	.072	.928
		Flowable composite	.137	.672
		Elastomer	.315	.099
	Self cure acrylic resin	Control	-.072	.928
		Flowable composite	.065	.908
		Elastomer	.243	.125
	Flowable composite	Control	-.137	.672
		Self cure acrylic resin	-.065	.908
		Elastomer	.178	.323
	Elastomer	Control	-.315	.099
		Self cure acrylic resin	-.243	.125
		Flowable composite	-.178	.323

p value obtained by performing Tuskey's HSD post hoc test

*- not significant- p value <0.05 is significant

Table-12

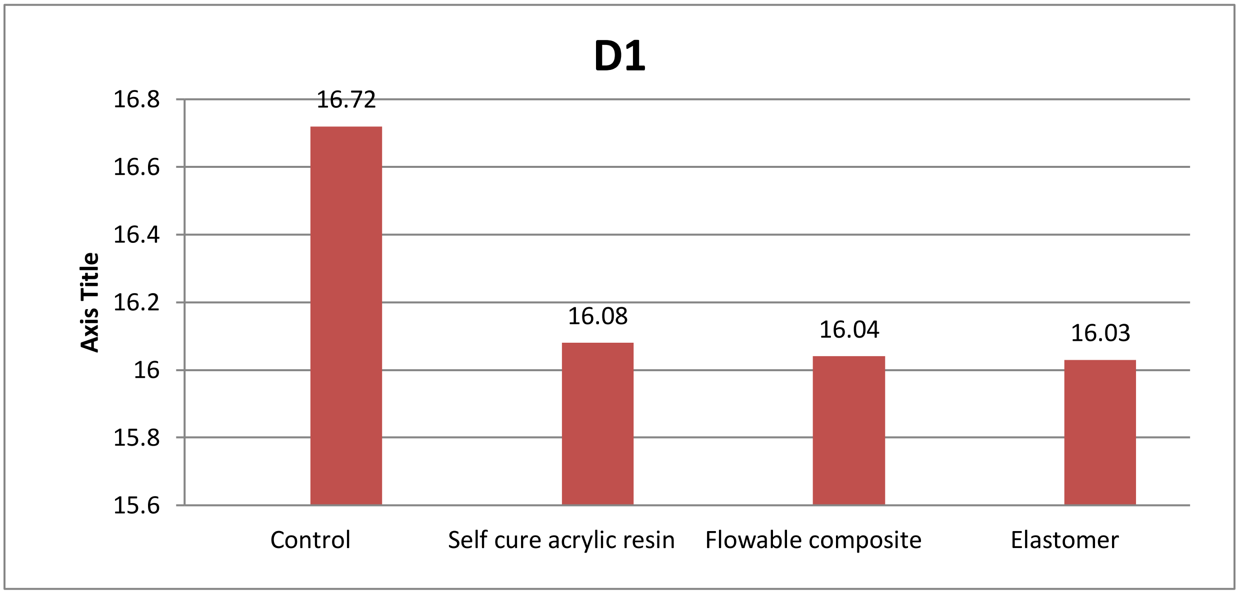
Difference in the inter-implant distance within the groups using tukeys post hoc tests in relation to D4

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p value
D4(mm)	Reference	Self cure acrylic resin	.280	.358
		Flowable composite	.290	.331
		Elastomer	.320	.258
	Self cure acrylic resin	Control	-.280	.358
		Flowable composite	.010	1.000
		Elastomer	.040	.990
	Flowable composite	Control	-.290	.331
		Self cure acrylic resin	-.010	1.000
		Elastomer	.030	.996
	Elastomer	Control	-.320	.258
		Self cure acrylic resin	-.040	.990
		Flowable composite	-.030	.996

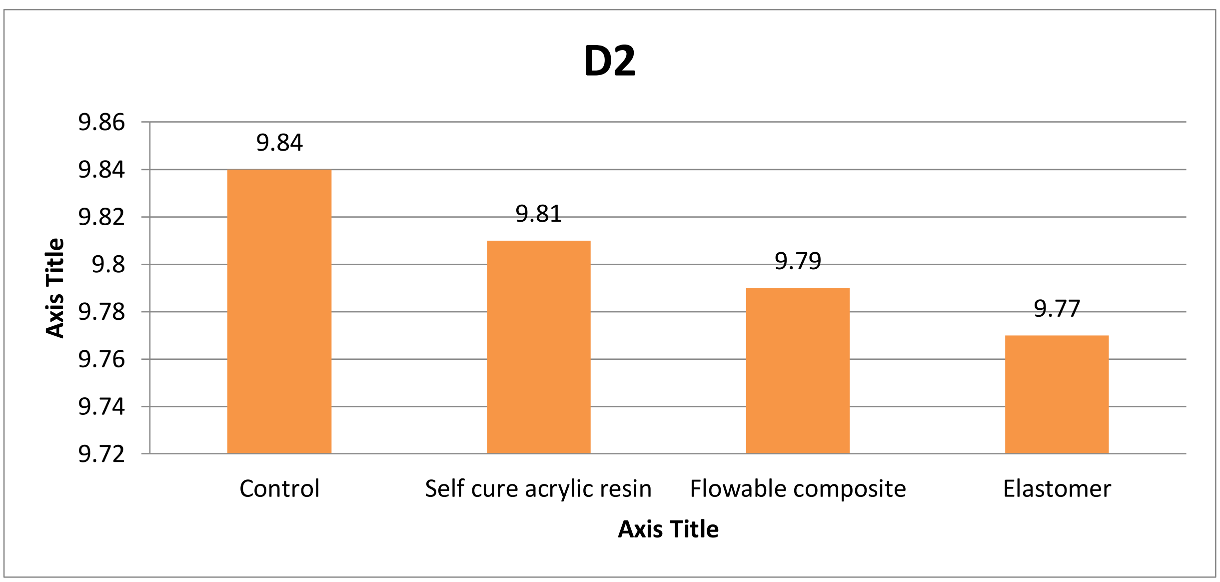
p value obtained by performing Tuskey's HSD post hoc test

*- not significant- p value <0.05 is significant

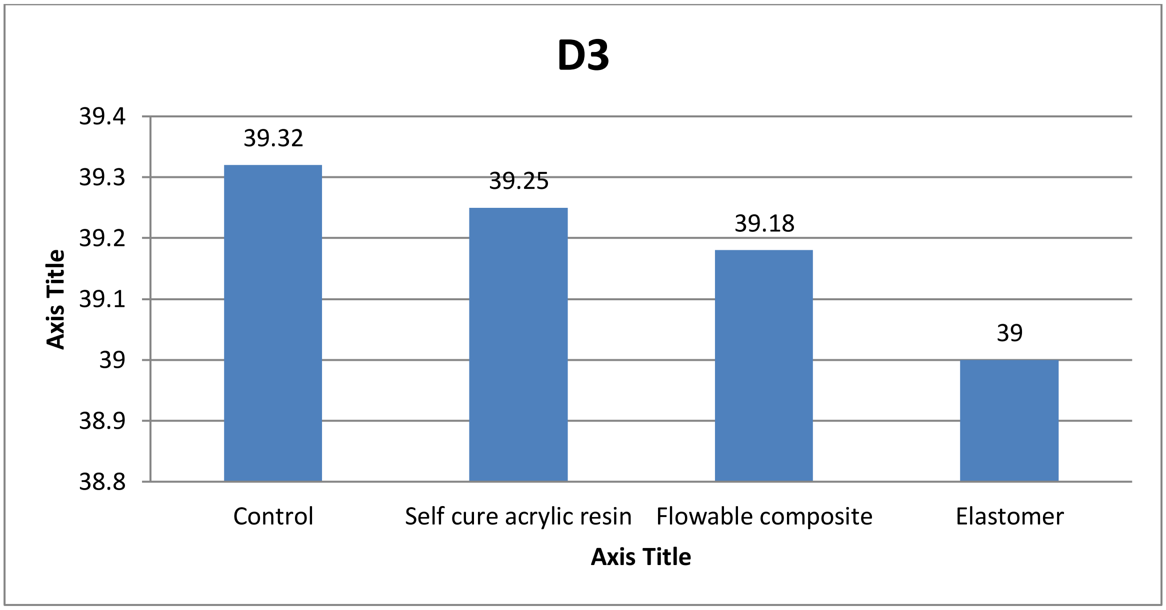
Graph-1: Distribution of the Mean values at D1 using different splinting materials



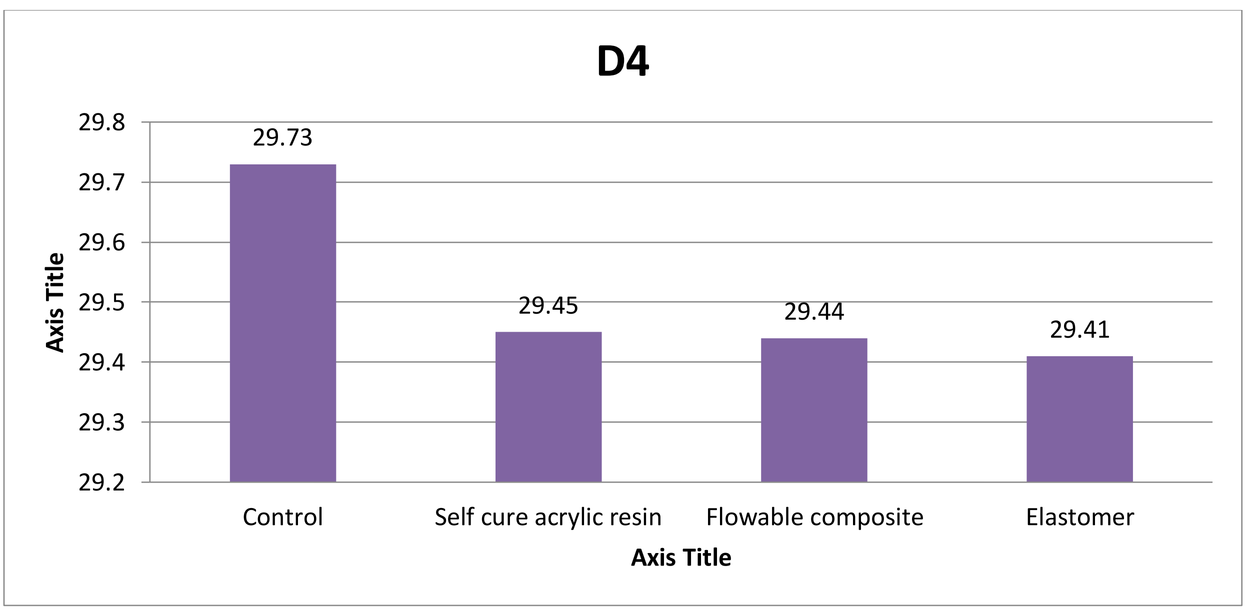
Graph-2: Distribution of the Mean values at D2 using different splinting materials



Graph-3: Distribution of the Mean values at D3 using different splinting materials



Graph-4: Distribution of the Mean values at D4 using different splinting materials



The results showed that,

1. The implant impressions made by direct technique using resin splinted impression copings, bis-GMA splinted impression copings and Polyvinyl siloxane splinted impression copings yielded master casts which had their readings very close to the reference model and within the clinical limits.
2. Splinting the impression coping with autopolymerizing resin, adequate polymerization time and compensation procedure before impression (Group A) was found to be statistically the most accurate method of splinting with its inter-implant distances showing less variation from the reference model.
3. Clinically acceptable accuracy could be obtained from the newer splinting methods using bis-GMA (Pro-temp 4 – syringable temporary crown material) and Polyvinylsiloxane (putty consistency).

DISCUSSION

The precise transfer of the spatial relationship of implants from the mouth to the master cast with an impression is the first and critical step to ensure passive fit of implant framework[28]. The ideal objective is difficult to realize clinically because of the potential for distortion of the master cast, which is caused by a combination of dimensional errors in the transfer process of the replicas, and also because framework adaptation may change when the retaining screws are tightened[37].

The impression which has to be replicated must be accurate so that the resulting master cast precisely duplicates the clinical situation. Most research indicates that direct techniques produce less distortion than indirect techniques[13, 45, 50]. Many impression techniques have been implemented to achieve master cast accuracy as well as a passive fit between the prosthesis and the osseointegrated implants[37, 40].

Branemark et al (1983)[9] showed the importance of splinting impression copings together before the impression. Splinting may provide stabilization of impression copings under torque for analogue tightening and reduce rotational freedom within a resilient impression material. Splinting is a determinant factor for the most accurate cast fabrication, regardless the impression material.

In this study a reference model with four implant analogues was used since the minimum number of implant suggested to support a fixed implant supported complete denture is four. This is an attempt made to compare the reliability of autopolymerizing pattern resin, bis-GMA (Pro-temp), and Polyvinylsiloxane in putty consistency as the splinting material. Light body and putty consistency polyvinylsiloxane was used as the impression material.

The drawback of the direct impression technique is the rotation of impression copings in the impression during fastening of the implant analog. In an absolute distortion analysis, an external reference point is used, while in relative distortion analysis one implant/replica is used as reference for measuring distortion[37]. Because the prosthesis connects all the implant together, the amount of strain on the implant is related to the relative positions of the implants to one another. Therefore, relative distortion analysis was done in this study by measuring the inter implant distances using a profile projector.

The results showed that,

4. The implant impressions made by direct technique using resin splinted impression copings, bis-GMA splinted impression copings and Polyvinyl siloxane splinted impression copings yielded master casts which had their readings very close to the reference model and within the clinical limits.
5. Splinting the impression coping with autopolymerizing resin, adequate polymerization time and compensation procedure before impression (Group A) was found to be statistically the most accurate method of splinting with its inter-implant distances showing less variation from the control model.
6. Clinically acceptable accuracy could be obtained from the newer splinting methods using bis-GMA (Pro-temp – syringable temporary crown material) and Polyvinylsiloxane (putty consistency).

The resin splinting group showed less error which could be attributed to the minimal shrinkage of the pattern resin used and the technique of splinting. The splint was sectioned in between the copings and then reunited which could have minimized the polymerization shrinkage. The amount of resin used for initial splinting could have not influenced the inaccuracy, but the dimension of the section made could have influenced the accuracy as it was joined again with resin before making impression. Further research on the dimensions of the splint and the dimensions of the section would shed light on the influence of resin shrinkage on the accuracy of impression. Also, the technique of resin splinting has differed among various studies done so far[57, 63, and 65].

Since bis-GMA (Pro-temp) and polyvinylsiloxane have not been tested for accuracy as a splinting material, data regarding the accuracy of these materials for splinting purpose is lacking. The values thus obtained for the materials used in this study are compared with the values obtained from the resin splinting group only (since enormous studies have been conducted for resin splinted copings). The range of differences obtained in bis-GMA splinted group with mean values (D1-16.04mm, D2- 9.79mm, D3-39.18mm and D4-29.44mm) and polyvinylsiloxane splinted group with mean values (D1-16.03mm, D2- 9.77mm, D3-39.39mm and D4-29.41mm) was almost in the similar range when compared to the resin splinted group with mean values (D1-16.08mm, D2- 9.81mm, D3-39.25mm and D4-29.45mm). These differences could be attributed to the rigidity of the splinting materials that was used to prevent the movement of copings in the vertical dimension during connection of the implant replica to the impression coping[57, 65].

From these data obtained, the inference of the study depends on the application of polyvinylsiloxane adhesive, polyvinylsiloxane impression material, rigidity of the splinting materials, tolerance between implant components and torque employed during fastening of the implant replica and could determine, either individually or collectively the extent of distortion[3,20].

In a study conducted by Sang-Jik Lee, David Assif and Ravi Shankar[18, 51, 57] on the accuracy of implant impression technique and the effect of splinting materials and methods, splinting the impression copings with autopolymerizing resin following compensation of polymerization shrinkage can enhance the accuracy of master cast and can be used as an effective splinting material for implant impression procedure was found to be statistically the most accurate method of splinting. The results obtained in the present study can be co-related to the results of the above mentioned study where splinting the impression copings with auto-polymerising resin showed better accuracy when compared to bis-GMA and polyvinylsiloxane.

Studies conducted by Heeje et al and Anil Sharma et al[4, 25] reported that greater accuracy of implant impressions was obtained with the splint technique than with the non-splint technique. The results can be co-related to this study where the splint technique is followed.

To conclude, the accuracy of the master cast obtained using direct impression technique with different splinting materials which has yielded positive results especially in relation to the use of auto-polymerizing pattern resin as it showed less amount of variation from the reference model when compared to polyvinyl siloxane (putty consistency) and bis-GMA (pro-temp – syringable temporary crown material) so it can be more suitably used as the splinting material.

After considering the various aspects of the present study and co-relating the results with the literature, it is concluded that improved accuracy of definitive cast was achieved with the use of autopolymerising resin (pattern resin).

LIMITATIONS:

1. The results obtained in the study can be related only to the type of the splinting materials used in the study and various factors involved in the procedure itself, like the implant angulation and the type of the final impression material used.
2. The accuracy of the master casts were evaluated based only on the inter-implant distances and not on the angular difference between the implant and replica to the base of cast.

CONCLUSION

An impression is a negative imprint that is used to make a positive replica of a structure for the production of a dental restoration or prosthesis. Since the accuracy of the impression affects the accuracy of the definitive cast, an accurate impression is essential to fabricate a prosthesis with good fit[56].

A faulty impression may result in prosthesis misfit, which may lead to mechanical and/or biological complications. Screw loosening and fracture, implant fracture, and other occlusal discrepancies have been reported as mechanical complications arising from the misfit of the prosthesis[66]. Biologically, marginal discrepancy arising from misfit may cause unfavourable soft and/or hard tissue reactions due to increased plaque accumulation.

In implant dentistry, a successful result can be achieved only when passively fitting prosthesis are fabricated. The application of undue torque to screws during attachment of the superstructure to the abutments can jeopardize the outcome. To eliminate discrepancies in the fit, it is essential that the work should be done on a master cast that reproduces, as accurately as possible as the position of the abutments in the patient's mouth. An important factor that influences the precision of fit is impression accuracy[28].

Literature shows that the accuracy of the implant cast depends on many factors such as the type of impression material, implant impression technique, the implant angulation, the die material accuracy, and the master cast.

The present in-vitro study was conducted to evaluate the effect of dimensional stability of conventionally used and novel splinting materials on the accuracy of master casts.
A reference acrylic resin model and a total of 12 master casts, four master casts for each group obtained by splinting the impression copings with Auto-polymerised pattern resin, Pro-temp TM (bis-GMA) syringable temporization material and Polyvinylsiloxane in putty consistency. The

reference acrylic resin model and the master casts were assessed using a profile projector to determine the inter-implant distances.

The results showed that the mean of the inter-implant distances in relation to the use of auto-polymerizing pattern resin showed less amount of variation from the reference model followed by Polyvinyl siloxane (putty consistency) and finally bis-GMA (Pro-temp 4 – syringable temporary crown material).

Within the limitations of the study, the following conclusions were made.

1. All the splinting materials yielded master casts which had their readings close to the reference model and within the clinical limits.
2. Among the splinting methods used in the present study, splinting the impression copings with Auto-polymerising resin (pattern resin) was more reliable than splinting with bis-GMA (Pro-temp 4 – syringable temporary crown material) and Polyvinyl siloxane (putty consistency).
3. Clinically acceptable accuracy could be obtained from the newer splinting methods using bis-GMA (Pro-temp 4 – syringable temporary crown material) and Polyvinylsiloxane (putty consistency).

Considering the various aspects of the present study, it is concluded that Autopolymerising (pattern resin) can still be the splinting material of choice to produce accuracy in the implant impressions followed by newer materials such as bis-GMA (Pro-temp 4 – syringable temporary crown material) and Polyvinyl siloxane (putty consistency).

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