EVALUATION OF ACCURACY OF CASTS OBTAINED FROM VARIOUS IMPLANT IMPRESSION TECHNIQUES

-AN INVITRO STUDY

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CERTIFICATE

This is to certify that the dissertation entitled **"EVALUATION OF ACCURACY OF CASTS OBTAINED FROM VARIOUS IMPLANT IMPRESSION TECHNIQUES - AN INVITRO STUDY"** is the bonafide work done by **Dr. T.BALA MURUGAN, during the period of 2008-2011** under our supervision and guidance and to our satisfaction. This dissertation is submitted in partial fulfillment , for the degree of Master of Dental surgery awarded by Tamilnadu Dr. M.G.R Medical university, Chennai in the branch I Prosthodontics and Crown & Bridge.

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CONTENTS

INTRODUCTION

INTRODUCTION

The goal of modern dentistry is to restore normal contour, function, comfort, esthetics, speech, and health, regardless of the atrophy, disease, or injury of the stomatognathic system. However, the more teeth missing for a patient, the more arduous this goal becomes with traditional prosthodontics. The patients need in the modern day dental practice are highly demanding. In order to meet the demands of the patients and to achieve higher goals a number of treatment techniques have evolved in the past decades. One such successfully emerged treatment technique is the dental implants. With the introduction of implants by Per Ingvar Branemark, the treatment modalities in dentistry have evolved by leaps and bounds. The implant treatments have overcome the various limitations of the conventional prosthetic treatment procedure. It has provided the perfect solution for the functional problems and psychological needs of the patient.

The elusive dream of replacing missing teeth with appropriate artificial substitutes has been part of prosthodontics from time immortal. Dental implants are the most exciting treatment concept to occur in dentistry. The opportunity now exists for the prosthodontist to rehabilitate patients to levels of form and function only dreamed just a few years ago. Dental implants are currently being used to, replace missing teeth, rebuild the craniofacial skeleton, provide anchorage for orthodontic treatment, form new bone in the process of distraction osteogenesis[25]

Many types of implants are now available for application in various clinical situations and all facets of dental profession especially prosthodontics becoming interested and involved in this modern form of treatment. The success of dental implants has revolutionized prosthodontics. There have been many advances in understanding the application of implant prosthodontics as a method for replacing missing teeth and craniofacial complex.

Advances in implant designs, materials, and techniques have led to predictable success in their application, and several types of implants are now available for use in rehabilitation of different clinical situations. Eversince the concept of osseointegration was first applied to human patients, there have been many advances in the understanding and application of implants as a method for the replacement of missing teeth. According to Glossary of Prosthodontic terms [45]

Dental implant is defined as a prosthetic device of alloplastic material(s)implanted into the oral tissues beneath the mucosal and / or periosteal layer, and /or within the bone to provide retention and support for a fixed or removable prosthesis; a substance that is placed into and/or upon the jaw bone to support a fixed or removable prosthesis [45].

In the past, many clinicians have attempted to use dental implants as a solution to edentulism and partial edentulism. Unfortunately much of their work has resulted in failure. One of the most important developments in modem prosthodontics has been the ability to replace missing teeth using titanium implants placed directly in to the jawbone. From one tooth up to a whole arch, or simply to stabilize a moving denture, implant dentistry can offer a successful alternative to many restorative problems. The security and comfort of a fixed restoration which looks and functions like real teeth cannot be over emphasized. However, without the work of the early investigators to build upon, we would not enjoy the success that we now have. It is critically important to understand how oral implantology has evolved in order to understand where we have been, and where we are going.

The success of the dental implants is influenced by various factors. One of the key factor affecting the outcome of the treatment is the impression procedure involved in the fabrication of implant prosthesis. The basic principle behind making an impression is to provide support, retention and stability for the prosthesis[17]. At the same time the impression should record all the potential prosthesis bearing surfaces available. The objective of making an impression in implant dentistry is to accurately relate an analogue of the implant or implant abutment to the other structures in the dental arch. This is affected by use of an impression coping which is attached to the implant or implant abutment. This impression coping is incorporated in an impression – much as a metal framework is 'picked up' in a remount impression for fixed prosthodontics. Increasing the number of components used for the transfer of the details from the patient to the casts increases the chances of error incorporated in the procedure involved. A variety of impression techniques for the fabrication of implant supported prosthesis have evolved in the past decade. The present study intends to compare the accuracy of two commonly employed techniques , the closed tray impression technique and the open tray impression technique.

In the past though many studies were done comparing the closed tray indirect transfer /open tray direct transfer impression techniques [3,4,47] , stock closed tray vs custom open trays [52] ,Impression materials (Vinyl polysiloxane vs Polyether) [7] and splinted vs non splinted transfer techniques [27,32,42,48,50, 62,80] but not much literature is available comparing the direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique. The present study compares the direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique made with a single impression material (Vinyl Polysiloxane).

AIMS & OBJECTIVES

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1. To evaluate the accuracy of casts obtained from closed tray and open tray impression techniques using two methods

    a. Electrical resistance strain gage

    b. Coordinate measuring machine

REVIEW OF LITERATURE

REVIEW OF THE LITERATURE

W. B. Eames et al (1979) [37] evaluated the effect of bulk on the accuracy of elastomeric impression materials. Impression trays were fabricated providing 2, 4, and 6 mm spaces to determine the stability and accuracy of nine elastomeric impression materials on a simulated full crown preparation steel die.The interface space of 2 mm produced the most accurate impressions for all of the materials tested.All impression materials except one fell within the revised American Dental association specifications.The clinical-type tests, using castings on dies poured from these materials, corroborated the acceptance of those materials and techniques exhibiting the least dimensional change.

Francis (1985) [41] described an impression procedure for the fabrication of Implant supported overdentures. He stated that the primary purpose of impression is to transfer the relationship between the nonyielding, osseointegrated fixture abutments and reproduce that relationship in the master cast. This can be achieved by the use of a rigid material that will eliminate the potential for distortion which is possible incase of using an elastic impression material.

Anthony, Den and Tjan (1986) [10] did a clinical evaluation of the accuracy of commonly used impression materials for the fabrication of implant supported prosthesis. In this study hydrocolloid and elastomeric impression materials were compared. They concluded that addition silicone and polyether impression materials were the best materials, because of their excellent dimensional stability. They remained accurate even after one week.

Amerian (1989) [9] did a study on the complications with osseointegrated implants. He stated that one of the most commonest complications in the fabrication of implant supported prosthesis is the failure to attain a passive fit which is basically due to the faults in the impression making procedure.

Mark, Terry and Jack (1990) [71] 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 they used 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 concluded that there was no significant difference between the three methods.

Robert M. Humphries et al (1990) [94] measured the accuracy of master casts fabricated from three impression techniques commonly used with the Brånemark System. Values from techniques using splinted and unsplinted squared polymer copings as well as unsplinted tapered hydrocolloid copings were not significantly different from values recorded from the master surrogate model. Tapered hydrocolloid copings yielded a higher correlation to coordinate values on the master than unsplinted square polymer copings or splinted square copings.

Alan B. Carr (1991) [3] investigated the accuracy of working casts fabricated from impressions using two different transfer copings as provided by a leading implant manufacturer,. A five-implant mandibular model was used to produce seven casts by both the indirect and direct transfer coping techniques. Comparison was made by using a dental cast framework fitted to the master cast. Differences in distances measured between each group and the master cast were analyzed to establish differences between methods. For the model used, the direct technique produced more accurate working casts.

Patten (1991) [87] did a comparative study on detail reproduction of soft tissue of various impression materials. This study compared the ability of several impression materials to register soft tissue without creating voids and produce detailed gypsum cast. They made impressions of the hard palate of a single subject using six commonly used impression materials. They concluded that polyether and hydrophilic addition silicone were best in detail reproduction.

Alan B. Carr (1992) [4] evaluated the accuracy of working casts produced from impressions using two different transfer copings in a 15-degree divergent two-implant posterior mandibular model. While the indirect method is less cumbersome to use, it was found to be less accurate in the prior study. The purpose of this study was to see if the direct method is more precise for this clinical situation. The results suggest no clear advantage in using the direct method in similar clinical situations.

Jose, Steven and Peter (1993) [59] did an evaluation of three impression techniques for osseointegrated oral implants.The purpose of this study was to evaluate the passive fit of the framework to the sample casts made by the three impression techniques. They concluded that none of the impression techniques resulted in a absolute passive framework fit.

Paolo Vigolo et al (1993) [79] compared the accuracy of three techniques used to fabricate master casts for implant prostheses. A metal model with six implants and standard abutments and a matching template were fabricated. Impressions of the model were made in Impregum and cast in Die Keen. Positional accuracy of the abutments was numerically assessed using an optical comparator. Visual analysis showed that only casts sectioned with the Zeiser system allowed a passive fit of the template. Statistical analysis of numerical findings indicated that casts made with the Zeiser system were significantly more accurate than solid casts, which in turn were more accurate than those made with the Pindex system.

David, Barry and Joseph (1994) [32] described a modified impression technique for implant supported restoration. In this technique they used a modified autopolymerizing resin custom tray to allow splinting of the impression copings directly to the tray. They stated that this method provides ease of manipulation, decrease in working time and splint distortion.

Jiunn, Ling and chen (1994) [54] described an accurate impression method for implant prosthesis fabrication. They stated that errors that result from the impression transfer method of implant position during the impression procedures often made it necessary to section and solder metal frameworks. In this technique they used a stone index, for the accurate transfer of the implant position to the master cast.

Walton J.N and Macentee (1994) [117] did a study on the problems associated with prosthesis on implants. In this study the prosthetic parameters included were patient satisfaction, prosthesis maintenance including adjustments and repairs. The patients were evaluated on the basis of satisfaction and maintainenance of the prosthesis. The results of the study showed that the most commonly needed adjustment is to contour the prosthesis.The patient satisfaction was quite high with implant supported prosthesis compared to other types of prosthesis.

Keith M. Phillips et al (1994) [62] compared the accuracy of three different implant impression techniques using (a) tapered copings, (b) square copings alone, and (c) square copings with an acrylic-resin splint. Total distortion was analyzed using a coordinate measuring machine with an accuracy of less than 1 µm. The statistical evaluations indicated (1) the square coping distortions were significantly smaller than the tapered coping values and (2) only the square coping distortions (no acrylic-resin splint) were not significantly different from the machining tolerances.

Badr Idris (1995) [14] compared the putty/wash one-step and two-step techniques for making addition silicone impressions. The results indicated that the interabutment distances increased slightly compared with the stainless steel model for both techniques, but the differences between techniques were not considered to be clinically important. The intraabutment measurements for the abutment without undercut increased, whereas abutments with undercuts decreased. These variations from the stainless steel model were also clinically insignificant.

Emad El Haje (1995) [38] introduced Direct impression coping for an implant system.

George C. Cho et al (**1995)** [43] studied the time-dependent bond strength of two polyvinyl siloxane impression materials to acrylic resin disks with their respective adhesives to determine the optimal time for maximum bond strength. The results indicated that the bond strength of the adhesive increased at least twofold from time zero to 7 minutes adhesive dry time and peaked at 60 minutes for one of the materials and at 8 hours for the other, Bond strengths increased rapidly to the 15-minute test interval and then seemed to plateau. Both materials exhibited decreased adhesive bond strengths at 24 hours.

Ashish kakar (1996) [12] described a simplified one step procedure for making impressions of implant supported reconstruction. In this technique the patient's existing denture is duplicated in clear acrylic resin. Then using this denture as a tray, impression is made with an elastomeric impression material.

Brent and Winston (1996) [19] did a study on compatibility of elastomeric impression materials for use as soft tissue casts. The author states that the communication of soft tissue contours from the clinical situation to the laboratory technician through the laboratory phases of the dental implant restoration is enhanced with the use of the soft tissue casts. His study states that the elastomeric impression materials can function well as both the master impression and soft tissue cast material.

David Assif et al (1996) [32] assessed the accuracy of three impression techniques in a laboratory cast that simulated clinical practice. The first technique used autopolymerizing acrylic resin to splint the transfer copings. The second involved splinting of the transfer copings directly to an acrylic resin custom tray. In the third, only impression material was used to orient the transfer copings. The accuracy of stone casts with implant analogs was measured against a master framework. The fit of the framework on the casts was tested using strain gauges. The technique using acrylic resin to splint transfer copings in the impression material was significantly more accurate than the two other techniques.

Torsten Jemt et al (1996) [114] did a study to statistically correlate in vivo measurements of prosthesis misfit and change of marginal bone level in implants placed in the edentulous maxilla. Measurements of prosthesis misfit were performed by means of a three-dimensional photogrammetric technique, and marginal bone levels were measured from standard intraoral radiographs. Results showed that none of the prostheses presented a completely passive fit to the implants in vivo. Furthermore, similar distortions of the prostheses were found in the two groups, indicating that the implants seem to be stable and do not move, even after several years in function. No statistical correlations ($P > .05$) between change of marginal bone levels and different parameters of prosthesis misfit were observed in the two groups. The study indicated that a certain biologic tolerance for misfit may be present. The degree of misfit reported in the study was clinically acceptable with regard to observed marginal bone loss.

Gamal burawi, Frank and Declan (1997) [42] studied on 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. Their analysis is based on the three factors the effect of technique, relative position of the implant on the cast, and plane of measurement. They concluded that the splinted technique exhibhited more deviation from the master model than the unsplinted model.

Stephen I. Riedy et al (**1997)** [102] evaluated the precision of fit between an implant framework and a patient simulation model that consisted of five implant abutments located in the mandibular symphysis area. One-piece cast frameworks were compared with Procera machined and laser-welded frameworks with laser videography. There were significant differences ($p < 0.05$) in the precision of fit between both the one-piece cast frameworks and the Procera frameworks, when compared with the abutments in the patient simulation model. The laser-welded framework exhibited a more precise fit than the one-piece casting, with significant differences at four of the five prosthodontic interfaces, when evaluated by the mean z-axis gap at the centroid points.

Souheil and Tanya (1997) [101] described a technique for a multiple implant cast fabrication in single visit. They used an open tray and acrylic resin to splint the transfer copings. In this process they sectioned and rejoined the resin between the transfer copings and then poured the impression by first joining the analogs with impression plaster, sectioned it, rejoined it again to stabilise the analogs and finally using dental stone to pour the impression. The advantage of this technique was it allowed fabrication of the final casting on the cast,thereby eliminating the clinical time necessary to obtain repetitive solder indexes, and thus minimizing inconvenience to the patient.

Belinda and Eugene (1999) [15] described a two step pick up impression procedure for implant retained overdentures. In this technique in the first step a conventional border molding was done and impression was made in an individualised tray that fits over the implant abutments. In the second step they attached the implant impression copings to the tray and then picked up the copings from the mouth.

Alvin (2000) [7] did an invitro study to compare the amount of torque required to rotate a square impression coping in an impression and evaluated the accuracy of solid implant casts fabricated from different impression materials. With a 1-way ANOVA, average torque values among the material groups differed significantly (P=.001). Polyether (medium consistency) was found to produce the highest overall torque values, followed by addition silicone (high consistency), and then polysulfide (medium consistency). Statistically significant difference was also found among the 3 material groups' mean absolute cast error using a 1-way ANOVA (P=.0086). Implant casts made from polyether (medium) or addition silicone (high) impressions were significantly more accurate than casts made from polysulfide medium impressions. On the basis of the results of this study, the use of either polyether (medium) or addition silicone (high) impression is recommended for direct implant impressions.

David A. Kaiser et al (2000) [34] described step-by-step procedures for the restoration of an ITI implant body with a solid abutment and cemented cast restoration. This impression system provides a simple and efficient method of transfer of implant position to the laboratory cast.

Herbst et al (2000) [48] did a comparative study on four impression techniques in terms of their dimensional accuracy to reproduce implant positions on working cast. They used four different impression techniques. They are tapered impression copings not splinted, squared impression copings not splinted, squared impression copings splinted with autopolymerizing acrylic resin, squared impression copings 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.

Michael Wise (2001) [72] did a study on the fit of implant supported fixed prosthesis fabricated on a master cast made from dental stone and dental plaster. An impression was made with patient’s replica and the inter – implant abutment distance was noted. Then casts were poured with conventional die stone and an ultra low expansion plaster. The results showed that the casts made from ultra low expansion plaster was more accurate compared to the conventional die stone.

Ali Mirfazaelian (2002) [6] described a time-saving method for impression making and abutment preparation performed as a laboratory procedure on multiple cement-retained ITI implants.

Jorge, Paul and Carlo (2002)[58] did a study to compare the dimensional accuracy of verification jigs with that of the conventional impression procedures and also the dimensional accuracy of three different resins for jig fabrication. They concluded that the accuracy provided by the verification jigs was not significantly superior to standard impression procedure and the jig fabrication does not improve the dimensional accuracy of the stone casts.

Joseph Nissan et al (2002) [61] described an implant impression technique for partially edentulous patients in which impression plaster and irreversible hydrocolloid are used. The technique ensures accuracy, ease of manipulation,and decreased working time.

Nopsaran, Nancy and stefaine (2002) [76] described a simple method for making an implant level impression when there is limited space, unfavourable implant positions and problematic angulations. In these conditions implant index copings can be used as an alternative. The two types of index copings are the titanium screw retained coping and plastic snap on version. Compared to the conventional ones these are smaller, easy to place and they require less chair time.

Song-Bor Kuo etal (2002) [99] described an efficient technique to obtain an optimal emergence profile for the definitive restoration of an ITI solid abutment when the implant is installed subgingivally and also reviews its advantages and disadvantages.

Yasuyuki and Masafumi (2002) [119] described a modified implant impression technique. In this the impression copings are seated on the implants and secured with the guide pins. Then an opening is made on the buccal side of the tray near the implants. Holes are prepared in the tray to allow the guide pins to protrude without contacting the tray during impression making. Then the area around the remaining teeth is recorded with a light body material. Inject the syringe through the holes made on the buccal sides of the tray. The material is allowed to set and the impression is removed along with the impression copings.

Jason, Richard and Leslie (2003) [52] 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. They concluded that the rigid custom trays produced significantly more accurate impressions when compared with the stock tray.

Paolo, Zeina and Giampiero (2003) [80] 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. They are nonmodified square impression copings, square impression copings joined together with autopolymerizing acrylic resin, square impression copings 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.

Assunco ,Wirley and Humbertoin (2004) [13] did an evaluation of transfer impressions for osseointegrated implants at various angulations. According to the author the accuracy of the impression plays an essential role in prosthesis implant adaptation. An accurate working cast depends on the impression material as well as the transfer techniques. In this technique a metal matrix containing four implants at various angulations were obtained using three impression techniques. The three techniques compared are indirect technique with conical copings in closed tray, direct technique with square coping in open tray, square copings splinted with autopolymerizg acrylic resin. The impression materials used are the four types of elastomeric impression materials. They concluded that the more perpendicular the implant analog angulation is in relation to the horizontal surface, the more accurate the impression.

Kivanc Acka et al (2002) [64] compared the accuracy of casts obtained with direct and indirect impression techniques and with polyether and Vinyl poly siloxane impression materials and concluded that the snap on VPS impression technique using a stock tray has the advantages of being clinically convenient and eliminates the need for repositioning after removal of the impression, resulted in accuracy similar to that achieved with Polyether direct impression technique.

Nickolas (2004) [75] 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 Monzavi (2005) [1] suggested the use of wax spacers for putty-wash impression of implant snap-on impression copings.

Richard (2005) [93] described a trayless impression technique for complete arch implant supported immediately loaded definitive restorations. In this technique the upper half of the impression copings are exposed and the elastomeric impression material is placed. Then light polymerized acrylic resin is applied to the upper half of the impression copings to engage their mechanical retentive features. Once the impression material sets it is removed from the mouth and then the cast is poured.

Brian Myung W. Chang and Robert F. Wright (2006) [20] suggested a technique of splinting implants together for impression with a vacuum formed bar and autopolymerising resin to reduce the amount of polymerisation shrinkage of them when used alone.

Bulent and Gozde (2006) [22] 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 inorder to record the alveolar mucosa in a functional state and the implant components accurately.

Chee and Jivraj (2006) [26] described impression techniques for implants. According to the author the object of impression making in implants is to accurately relate an analoge 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 incases 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 moth together with the set impression.

Murat and Acka (2006) [73] did a study on the misfit induced strains on implant supported superstructures by the impression techniques. In this study a master cast hosting four sraumann implants was constructed. On this cast impressions were made by direct technique using a polyether impression material and screwed aluminium impression caps and by the indirect technique using polyvinylsiloxane impression material using snap on impression caps. Then linear gauges were bonded on the superstructures and the misfit induced strains were recorded. They concluded that the snap on direct impression technique produced a much acceptable superstructures.

Richard and Thomas (2006) [91] described a simple open tray impression technique for implants. This technique makes use of a soft boxing wax which is easy to apply and remove. The advantage of this technique is it is easy to perform and it is inexpensive.

Bulent Uludag and Volkan Sahin (2006) [23] described a functional impression technique for implant retained overdenture. It is a two step technique. In this technique the impression of the alveolar mucosa is made with ZnoE impression paste. Then the impression of the ring abutments were made with low viscosity elastomeric material. The advantage of this technique is, it records the alveolar mucosa in a functional state and the implant components accurately.

Bi-Yuan Tsai (2007) [17] suggested a novel technique of using provisional restoration as the implant impression copings.

Cabral, Leonardo and Carlos (2007) [24] did a comparative analysis of four impress techniques for implants.The four impression techniques compared are closed impression technique with tapered transfer copings, open tray impression technique with unsplinted squared transfer copings, open tray impression technique with squared transfer copings splinted with acrylic resin, open tray impression technique with squared transfer copings with acrylic resin splints sectioned 17 minutes after setting and welded with the same resin. The mean distances were calculated from 3 measurements for each sample in the master cast and in the master metal framework. They concluded that the open tray impression technique with squared transfer copings with acrylic resin splints sectioned and welded after setting had better results than the oher techniques studied.

Heather, Pesun and James (2007) [47] 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 inorder 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 combined interaction of impression technique and angulation had no effect on the accuracy of the cast.

TERMINOLOGIES

TERMINOLOGIES [45]

A generic language for endosteal implants has been developed by Misch and Misch. It is presented in an order following the chronology of insertion and restoration.

Dental implant [45] : 1. a prosthetic device made of alloplastic material(s) implanted into the oral tissues beneath the mucosal or/and periosteal layer, and on/or within the bone to provide retention and support for a fixed or removable dental prosthesis; a substance that is placed into or/and upon the jaw bone to support a fixed or removable dental prosthesis 2. the portion of an implant that provides support for the dental implant abutment(s) through adaptation upon (eposteal), within (endosteal), or through (transosteal) the bone.

Impression [45] is defined as the negative replica of teeth and the oral tissues[11]. A good impression forms the basis for a successful prosthetic treatment. The oral environment presents a challenging task for the dentist, which he has to replicate for the fabrication of various prosthesis. In order to achieve a proper impression one should have a knowledge of the oral anatomy, various impression techniques, material science of the impression material being used. Furthermore the skill and appropriate selection of the material and technique plays a significant role.

Dental impression [45] : a negative imprint of an oral structure used to produce a positive replica of the structure to be used as a permanent record or in the production of a dental restoration or prosthesis.

Impression technique [45] : a method and manner used in making a negative likeness (GPT-4).

Elastomeric impression material [45]: a group of flexible chemical polymers, which are either chemically or physically cross-linked. Generally, they can be easily stretched and rapidly recover their original dimensions when applied stresses are released.

Model [45] : a facsimile used for display purposes; a miniature representation of something; an example for imitation or emulation.

Cast [45]: a life-size likeness of some desired form. It is formed within or is a material poured into a matrix or impression of the desired form**.**

Stock tray [45] : a metal prefabricated impression tray typically available in various sizes and used principally for preliminary impressions.

Custom tray [45]: an individualized impression tray made from a cast recovered from a preliminary impression. It is used in making a final impression.

Dental casting investment [45] : a material consisting principally of an allotrope of silica and a bonding agent. The bonding substance may be gypsum (for use in lower casting temperatures) or phosphates and silica (for use in higher casting temperatures).

Surfactant [45] : a surface active substance (as a detergent) applied to a substrate to facilitate its wetting by another material.

Casting [45] : something that has been cast in a mold; an object formed by the solidification of a fluid that has been poured or injected into a mold.

Casting ring [45]: a metal tube in which a refractory mold is made for casting dental restorations.

Casting wax [45] : a composition containing various waxes with desired properties for making wax patterns to be formed into metal castings.

Abutment [45] : that part of a structure that directly receives thrust or pressure; an anchorage 2: a tooth, a portion of a tooth, or that portion of a dental implant that serves to support and/or retain a prosthesis.

Superstructure [45] is defined as a metal framework that fits the implant abutments and either provides retention for a removable prosthesis (e.g., cast bar retaining an overdenture with attachments) or provides the framework for a fixed prosthesis.

A **transfer coping** [45] is used in traditional prosthetics to position a die in an impression. Most implant manufactures use the terms transfer and/or coping to describe the component used for the final impression. Therefore a transfer coping is used to position an analog in an impression and is defined by the portion of the implant it transfers to the master cast, either the implant body transfer coping or the abutment transfer coping.

An **indirect transfer coping** [45] uses an impression material requiring elastic properties. The indirect transfer coping is screwed into the abutment or implant body and remains in place when the set impression is removed from the mouth. The indirect transfer coping is parallel-sided or slightly tapered to allow ease in removal of the impression and often has flat sides or smooth undercuts to facilities reorientation in the impression after it is removed.

A **direct transfer coping** [45] usually consists of a hollow transfer component, often square, and a long central screw to secure it to the abutment or implant body. After the impression material is set, the direct transfer coping screw is unthreaded to allow removal of the impression from the mouth. Direct transfer coping takes advantage of impression material having rigid properties and eliminates the error of permanent deformation because it remains with in the impression until the master model is poured and separated.

An **analog** [45] is something that is analogous or similar to something else. An implant analog is used in the fabrication of the master cast to replicate the retentive portion of the implant body or abutment (implant body analog, implant abutment analog). After the master impression is obtained, the corresponding analog (e.g., implant body, abutment for screw) is attached to the transfer coping and the assembly is poured in stone to fabricate the master cast.

A **prosthetic coping** [45] is a thin covering, usually designed to fit the implant abutment for screw retention and serve as the connection between the abutment and the prosthesis or superstructure. A prefabricated coping usually is a metal component machined precisely to fit the abutment. A castable coping usually is a plastic pattern cast in the same metal as the super structure or prosthesis. A screw retained prosthesis or superstructure is secured to the implant body or abutment with a prosthetic screw.

MATERIALS AND METHODS

Materials

Master Model - Columbia dentoform V50 L brass model

Dental Implants - 2 endosseous root form implants (D 3.75 , L 10 mm,

platform - 3.5 mm)

Drill - Iron drill (3.75mm diameter)

Lead - Fixing implant to the model

Castable abutments - 2 UCLA abutments for 3. 5mm diameter internal hex implant

Pattern wax – Pattern wax

Debubbliser – Surfactant

Silicone casting ring – Size no. 2

Kavovest – Phosphate bonded investment

Wax Burnout furnace

Alloy for casting bar assembly - Nickel Chromium alloy

Impression tray

Stock tray – Dentulous perforated stainless steel tray

Custom Tray – Light cure resin tray

Tray adhesive

Implant analogues – 3.5 mm analogues

Light cure chamber

Vinyl handgloves

Direct impression coping for closed tray internal hex – 2 no.s

Direct impression coping for open tray internal hex – 2no.s

Spacer for light body in open tray impression technique - Modified Needle cap. The needle cap of a 0.55*25mm needle (of 3ml syringe) is cut to the measure of a little more than the vertical dimension of open tray impression transfers so that they cover them while making putty impression for the study in the model.

Addition polymerizing silicone

Type IV - Dental stone, high strength (class II stone or Densite)

Hand wrench

The Strain Gage

The most common method of measuring strain is with a strain gage, a device whose electrical resistance varies in proportion to the amount of strain in the device. The most widely used gage is the bonded metallic strain gage.

The metallic strain gage consists of a very fine wire or, more commonly, metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of metallic wire or foil subject to strain in the parallel direction. The cross-sectional area of the grid is minimized to reduce the effect of shear strain and Poisson Strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen. Therefore, the strain experienced by the test specimen is transferred directly to the strain gage, through the wire connected to it , which responds with a linear change in electrical resistance.

Coordinate Measurement Machine (C.M.M)

The coordinate measuring machine used in the study is a moving bridge type machine. The electrical resistance strain gage gives the change in x and y axes only. The change in the angularity or the z axis cannot be determined with the strain gage. Hence a coordinate measuring machine was used. The change in the x, y, z axes and the angularity of the abutments placed in master model and samples are given accurately by the stylus with ruby ball tip of the measuring arm.

Method

Fabrication of Master Model :

Master model was prepared by making 2 parallel vents of 3.75mm size on either premolar region of Columbia dentoform V50 L brass model (Columbia dentoform Corp, New York - Fig 1,2) so that the vent can accommodate an endosseous root form implant of 3.75mm size – MIS, Israel, (Fig 3). Implants were positioned in the holes and fixed in position with molten lead poured from the base side of the model. Implant platforms were placed such that they were at the crestal level of the ridge of the model imitating two implants placed intraorally (Fig. 6).

Bar Fabrication :

A bar (Cobalt Chromium) was constructed with two castable abutments (UCLA abutments for 3. 5mm diameter internal hex implant – Fig. 7).The UCLA castable attachments were placed inside the implants engaging the internal hex and screwed into position with fixation screws using hex driver. The bar was waxed up joining the abutments from the mesial of one castable abutment to the mesial of the other abutment (Fig. 8). Castable abutment – bar complex was waxed up and sprued at 4 points (2 sprue channels for each castable UCLA abutments & 2 sprue channels for bar at equal distance – Fig. 9) . Then the bar castable abutment waxed complex was unscrewed with hex driver carefully without distortion. Then the complex was sprayed with surfactant spray (Debubbliser, DP Dental products, India.) before investing with phosphate bonded investment (Kavovest). The wax pattern was fixed to the crucible former in proper position and silicone casting ring was placed over the pattern in the center of it leaving adequate space for investment cover at the top end (6mm) (Fig. 10,11) . The phosphate bonded investment was mechanically mixed under vacuum (Fig. 12) (Vacuumyx, Confident dental equipments, India) as per manufacturers instructions. Before pouring the investment the pattern was coated with thin layer of investment using a small brush to prevent air void formation on the surface of pattern. Then the pattern was invested (Fig. 13). Once the investment was set it was removed off the silicone casting ring (Fig. 14,15). The furnace was preheated to 950°C. Then the wax elimination was done with high heat thermal expansion technique. The invested pattern was placed inside the wax burnout furnace for 30 mins and maintained at the same temperature for complete wax elimination and adequate thermal expansion to occur. Then the investment was casted with molten cobalt chromium alloy (Type IV Hi-Chrome Soft) in Induction casting machine (Manfredi, Century, Italy.). After allowing the casting to cool it was quenched and the casted bar was retrieved off the investment (Fig. 16). The bar was cleaned, trimmed and smoothly finished without disturbing the hex of the abutment (Fig. 17). Then the bar was fixed on the implants and checked for the fit. To make the seating of the bar on the implants strain free (0 Strain value) the cast bar was cut right in the middle while screwed in position with hand wrench (Torque at 10 Ncm) and laser welded with Bego laser welding machine (Fig. 18,19) . The passivity of the fit of the bar was checked with strain gauge, attaching the arms of the electrical strain gauge at the middle of the bar and considered as control.

Preparation of Sample casts :

The sample size for the study was 20 casts i.e., with closed tray impression technique (with pickup posts) 10 casts and open tray impression technique 10 casts.

Closed tray impression technique :

Closed tray impressions were made with dentulous perforated stainless steel stock trays - Size L 3 (GDC) (Fig. 21) using Vinyl polysiloxane impression material (Express STD, Putty and Light body , regular set , hydrophilic impression material , 3 M ESPE , U.S.A – Fig. 24, 25) .Manufacturer's recommendations were followed during material manipulation. In this technique first the closed tray direct impression transfers (MIS – for internal hex implants) were screwed into position over the implant fixtures placed in the master model using hex driver with finger pressure (Fig. 22) . During the placement care was taken that the flat surface of the closed tray impression transfers face the buccal side (Fig. 23) . Then the pickup transfer copings were inserted with firm finger pressure over the closed tray transfers aligning the flat internal facet of them with the flat buccal surface of the closed tray transfers (Fig. 28). Their complete seating was visually confirmed . Tray adhesive (3M ESPE) for Vinyl polysiloxane impression material was coated in a thin layer over the selected tray on the inside surface and over the borders. Tray adhesive was allowed to dry for 5 mins. For making impression double mix double take technique was followed. The base and catalyst of putty consistency material (ISO 4823 – Elastomeric impression material, Type 0 consistency) were hand mixed by wearing vinyl gloves. Stock tray was loaded with the putty mix (Fig. 27) and it was pressed over the model (Fig. 29). Once the material was set the impression was removed along with the pick up transfer. Then the pickup transfer coping was removed from the impression together with some putty material around the coping with putty knife creating adequate space for light body . (Fig. 30, 31, 32) Then the coping was cleaned off so nos putty stick around it and then placed firmly back in its position over the closed tray impression transfer aligning the flat internal surface with it. Then the light body (ISO 4823 – Elastomeric impression material, Type 3 consistency) was injected around the closed tray impression transfers and the space previously occupied by the transfer coping in the impression tray (Fig. 33). Then the tray was inverted over the master model and pressed into position. Material was allowed to set and the tray was removed (Fig. 34)along with pick up transfer copings in the impression. The closed tray transfers were unscrewed from the fixtures using hex driver. The closed tray transfers were then joined with implant analogues (MIS – 3.5mm analogues for internal hex) by screwing them with finger pressure with hex driver (Fig. 35). The closed tray transfer analogue assembly was placed inside the pickup transfer coping in the impression and checked for complete seating visually (Fig. 36, 37, 38) The impression surface was sprayed with surfactant spray (Debubbliser ,Prime Dental Products – Fig 40, 41) and the impression was poured with Type IV (Kalrock, Pink, Kalabhai Karson Pvt. Ltd, Mumbai, India. high strength, low expansion) die stone. Die stone was mechanically mixed under vacuum for 45 secs according to manufacturers instruction and poured into the impression without disturbing the analogues. Allowed to set for 40 mins then cast was retrieved with closed tray transfer. Then the closed tray transfer was unscrewed from the analogue with hex screw. Base was poured and finished. They were numbered as CT for closed tray followed by the impression number for all the ten samples (Fig. 42)

(i.e., CT - 1,CT - 2,CT - 3, CT - 4, CT - 5, CT - 6, CT - 7, CT - 8,CT - 9,CT - 10).

Open tray impression technique

For open tray impressions, custom trays were fabricated with light polymerising resin trays (Delta, India) and a spacer made of uniform thickness heat cure acrylic resin (Trevalon denture base material- Clear) template (Fig. 43) . The heat cure spacer with three tissue stops – one in the anterior midline and two in the eitherside molar regions was constructed by adapting 4 wax sheets (Hindustan Modelling Wax Medium) over the cast obtained from the impression of the master model and heat processed. .Then the light cure resin tray was adapted over this spacer and polymerized in the light cure chamber (Blu Lux, Delta, India) (Fig. 46). One tray handle was placed in the anterior region and two on the posterior molar regions (dimension 8× 8 × 3 mm). 2 vents were cut over each implant leaving enough clearance for open tray impression posts to be exposed before light polymerisation of the trays. After polymerisation of trays the acrylic spacer was removed from the tray. This procedure was done for all the 10 custom trays constructed (Fig. 47). Thus the spacer with tissue stops ensure uniform thickness of the putty impression material for all the impressions made. Once the tray was ready the tray was coated with tray adhesive for Vinyl polysiloxane impression material and allowed to dry for 5 mins (Fig. 51). Meanwhile the open tray impression transfers were screwed into the implant fixtures in the master model using the hex driver (Fig. 48). The impressions were made with double mix double take technique. Before making impression the modified needle cap (spacer for light body) was placed over the open tray transfers (Fig. 49) which prevented the adherence or locking of putty material to the transfer coping.. The putty material was loaded in the impression tray, pressed into position over the model, excess material around the spacer was removed before the set of the putty material (Fig. 52, 53, 54). Adequate pressure was applied so that all the three tissue stops were seen exposed in the impression.. Once set, the impression was removed (Fig. 55). Then the modified needle cap spacer was removed from the impression, relief was given using putty knife to create adequate space for light body (Fig. 56). The light body material was loaded in the space occupied previously by the modified needlecap in the tray and around the open tray impression transfers in the model (Fig. 57) . Then the impression tray was pressed into position over the master model (Fig. 58, 59). During set of the material the excess impression material that flowed out of the vent was removed with finger exposing the open tray transfer fixation screws properly (Fig. 60). Once the material was set the open tray impression transfer was unscrewed from the implant fixture in the master model with hex driver and the impression was removed (Fig.61)with the open tray transfers intact (Fig. 62). Holding the open tray impression transfer firmly in position with left hand index finger implant analogue was connected with it by screwing it in position with hex driver (Fig. 63, 64, 65). Then the impression surface was sprayed with surfactant spray (Debubbliser) (Fig 67) and the impression was poured with Type IV die stone – Fig. 68. Die stone was mechanically mixed under vacuum for 45 secs according to manufacturers instruction and poured into the impression. Allowed to set for 40 mins then cast was retrieved after unscrewing the fixation screws of the open tray transfers (Fig. 69). Casts were finished & polished. Casts were coded for the technique and the number of the impression. Totally 10 impressions were made for open tray technique and the casts were coded as OT - 1, OT - 2, OT - 3,OT - 4,OT - 5,OT - 6,OT - 7,OT - 8, OT - 9,OT - 10. (Fig. 70)

Procedure for analysis of accuracy using Strain gage :

The casts were analysed for accuracy comparing them with master model by screwing the bar (with hand wrench at 10 Ncm) constructed in master cast , with each cast and attaching the electrical resistance strain gage (Digital strain indicator SI 30, SYSCON company – Fig. 72) to the horizontal portion of the bar(Middle) (Fig. 71). The readings obtained were tabulated for each cast and were statistically analysed.

Procedure for analysis of accuracy using Coordinate Measuring machine :

The accuracy was also compared by measuring the change in the coordinates of the abutments with the coordinate measuring machine (C.M.M – TESA Microhite 3D, TESA Technologies - Fig. 76).With this technique the standard abutments (MIS Dental Implant systems , Israel – Fig . 78) for 3.75mm dia internal hex implants was screwed into the master model implants with hex driver under finger pressure. This model was placed in the coordinate measuring machine and the coordinates of the abutments (screwed with torque of 10 Ncm – Fig 73) were recorded from the central axis of them. (Fig. 79). Then the abutments were unscrewed and screwed with fixation screws (with torque of 10 Ncm) on to the sample casts obtained with closed tray and open tray impression techniques (Fig. 81, 82). Then this cast is placed in the coordinate measuring machine and the x, y, coordinates and angularity of abutments are measured and recorded. Then the difference in the coordinates of the two abutments between the master model and the cast is calculated and tabulated for individual casts from CT – 1 to CT – 10 and OT – 1 to OT - 10. The measurements were statistically analysed. The least the amount of strain produced in the bar and least the amount of difference in the x,y axis and angularity from the master model after statistical analysis gives the accurate cast and the accurate technique employed in making the implant impressions.

PHOTOGRAPHS

Fig 1 Edentulous Mandibular brass model (Columbia Dentoform V50L)

Fig 2 Edentulous Mandibular brass model (Columbia Dentoform V50L)

Fig 3 Dental Implant (MIS)

Fig.4 Drilling vents in brass model for implant placement

Fig.5 Implants in position

Fig. 6 Implants placed at the crest of the ridge

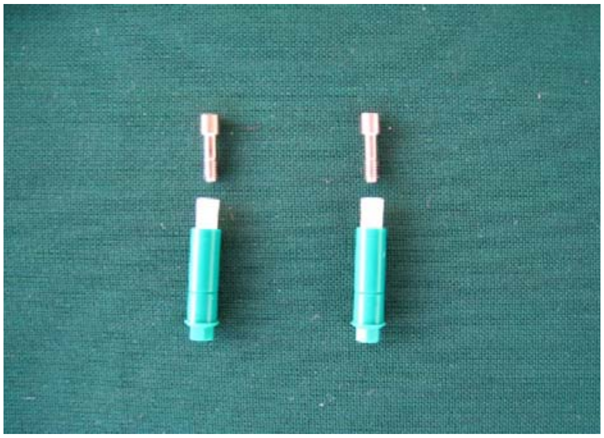


Fig. 7 Hex UCLA castable abutment for Internal hex Implant

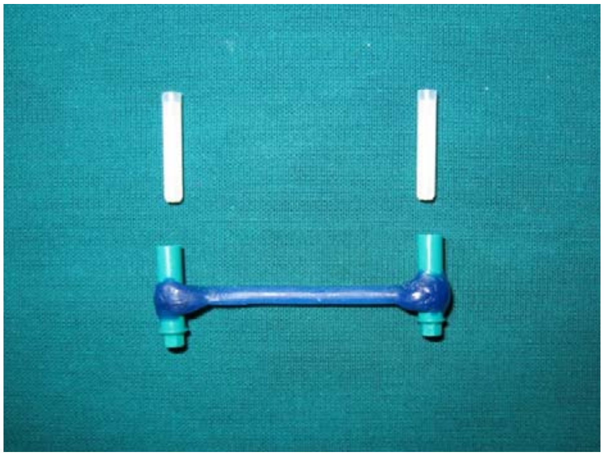


Fig. 8 Wax pattern of bar assembly

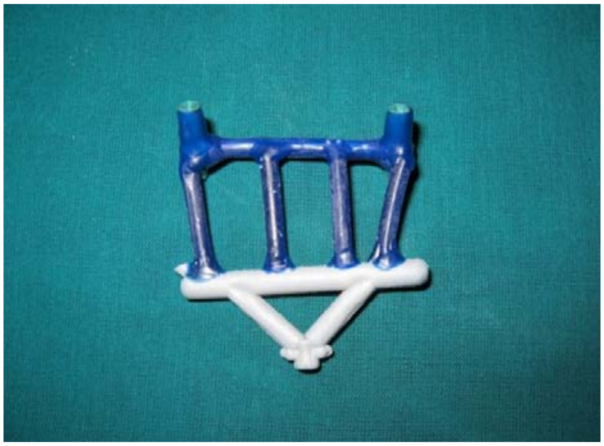


Fig. 9 Sprued wax pattern for casting

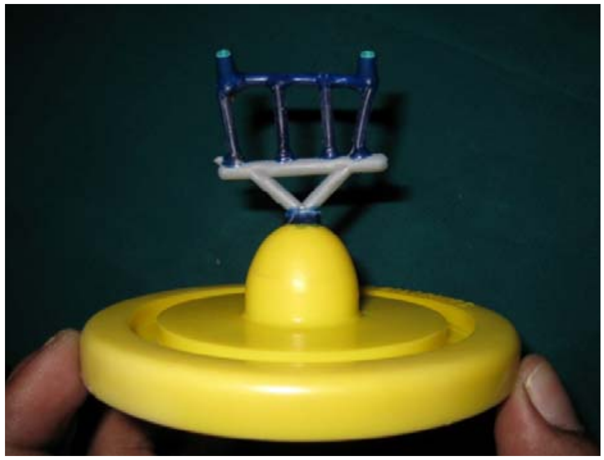


Fig. 10 Sprue former attached to pattern

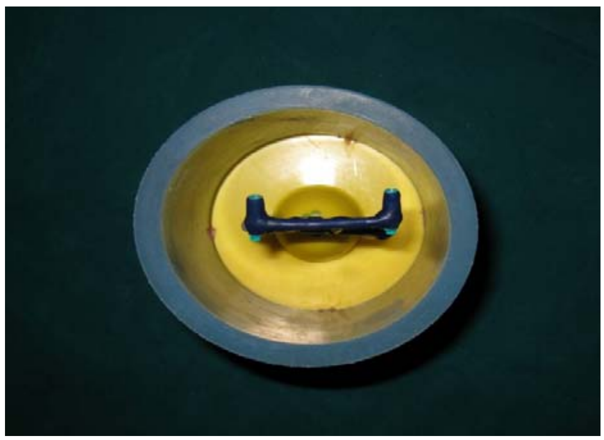


Fig. 11 Wax pattern ready for investment inside casting ring

Fig. 12 Phosphate bonded investment with solvent

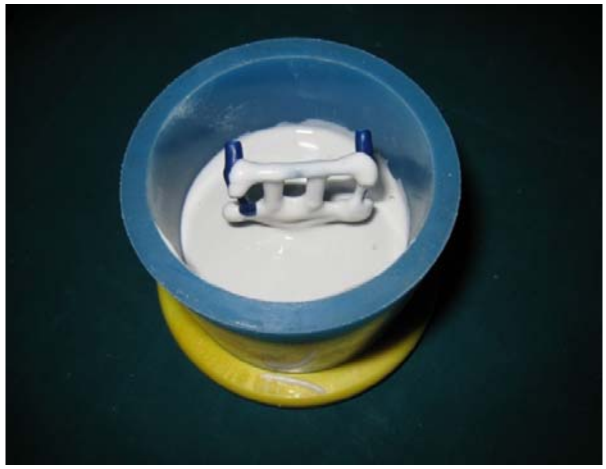


Fig. 13 Invested pattern

Fig. 14 Sprue former removed

Fig. 15 Casting ring removed for ringless casting

Fig. 16 Cast bar retrieved from investment

Fig. 17 Finished Bar

Fig 18 BEGO Laser welding Machine

Fig. 19 Laser welded bar

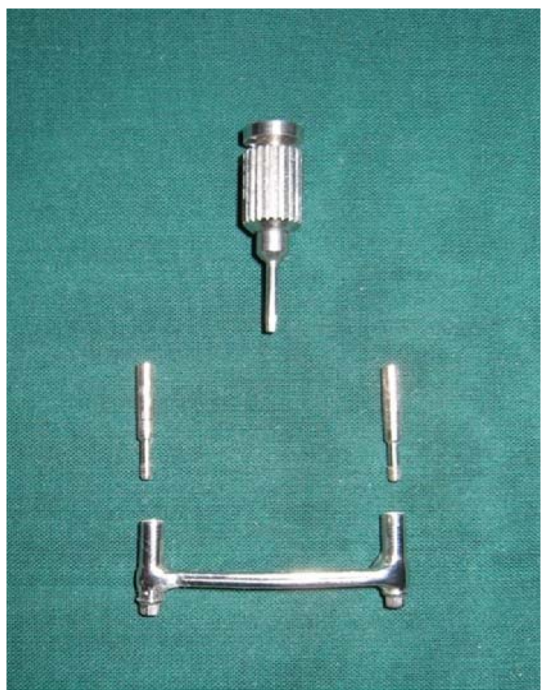


Fig. 20 Bar assembly with fixation screws and hex driver

Fig. 21 stock trays for closed tray impression technique

Fig. 22 Direct impression coping for closed tray internal hex

Fig. 23 Direct impression coping for closed tray internal hex in position with flat surface facing buccal

Fig. 24 Vinyl polysiloxane impression material putty

(Express STD , 3M ESPE)

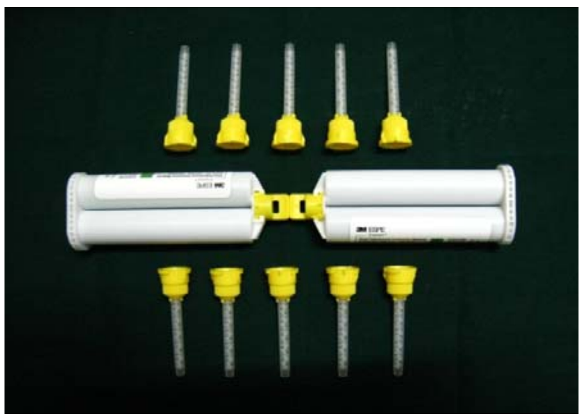


Fig. 25 Vinyl polysiloxane impression material light body (Express STD ,

3M ESPE) with spiral mixing tips

Fig. 26 Light body dispensing gun (Garant , 3M ESPE) with spiral mixing tips & intraoral tips

Fig. 27 Putty mix loaded in stock tray for closed tray impression technique

Fig. 28 Pickup posts seated in position

Fig. 29 Stock tray inverted over the model (Closed tray impression)

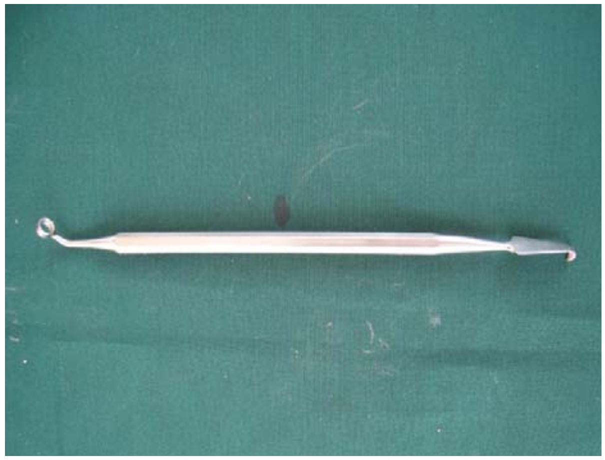


Fig. 30 Putty scrapper

Fig. 31 Putty around pickup posts cutoff

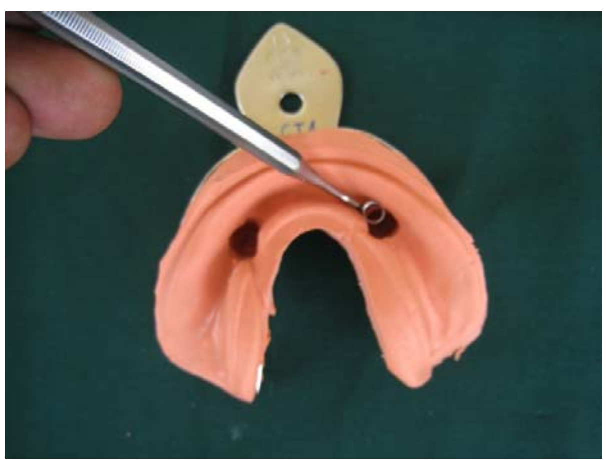


Fig. 32 Removal of pickup posts from the set putty impression

Fig. 33 Light body VPS injected around pickup posts & space occupied by them in the impression

Fig. 34 Set impression with pickup posts

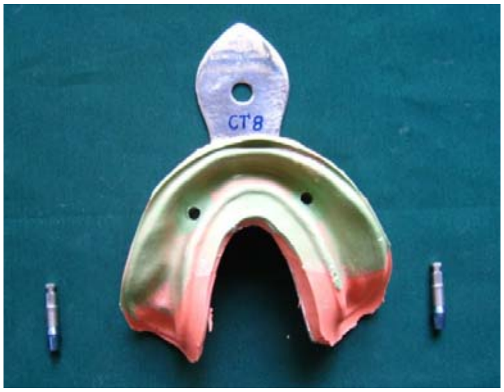


Fig. 35 Connected implant analogue with direct impression coping for closed tray internal hex using hex driver

Fig. 36 Flat internal surface of pickup posts

Fig. 37 Inserting analogue - direct impression coping for closed tray internal hex complex aligning with the flat internal surface of pickup posts

Fig. 38 Analogues in position before pouring the impression

Fig. 39 Closed tray impressions before pouring with die stone

Fig. 40 Surfactant spray for elastomeric impression

Fig. 41 Surfactant sprayed over impression surface before pouring impression

Fig. 42 Models poured, finished and coded

Fig. 43 Autopolymerising resin spacer with tissue stops & vents over implants

(for open tray impression technique)

Fig. 44 Tissue stops filled with light cure resin material

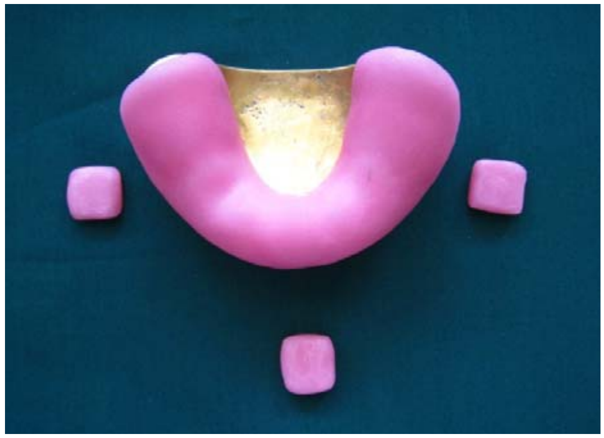


Fig. 45 Light cure resin tray with handles

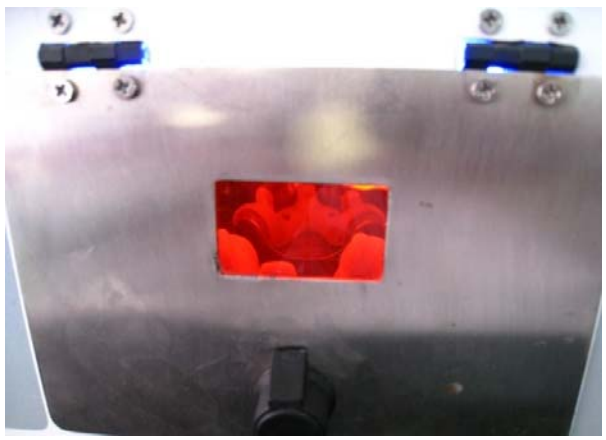


Fig. 46 Light curing of resin custom trays in Blu Lux curing unit (Delta)

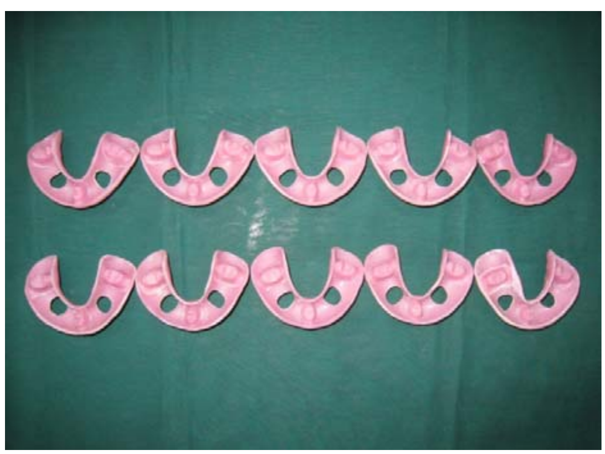


Fig. 47 Custom trays for open tray impression technique

Fig. 48 Direct impression coping for open tray internal hex screwed into position with flat surface aligned to buccal

Fig. 49 Spacer placed over direct impression coping for open tray internal hex to provide uniform space for light body

Fig. 50 Open tray tried in for seating without interference

Fig. 51 Tray adhesive coated on the custom tray

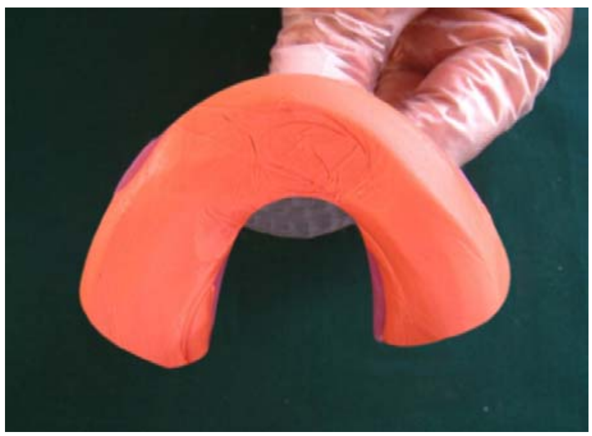


Fig. 52 Putty mix loaded in the tray

Fig. 53 Custom tray pressed into position over the master model

Fig. 54 After removal of excess from around the direct impression

coping for open tray internal hex

Fig. 55 Set impression removed with spacer

Fig. 56 Spacer removed from the set impression

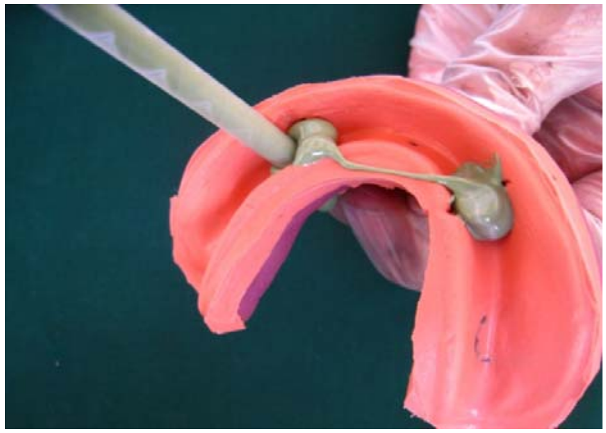


Fig. 57 Light body injected in the vent produced by spacer

Fig. 58 Light body injected around direct impression coping for open tray internal hex with intraoral tip

Fig. 59 Tray inverted into position over the master model

Fig. 60 After removal of excess light body extruded through the vent

Fig. 61 Fixation screws unscrewed using hex driver

Fig. 62 Removal of the set impression with direct impression coping for open tray internal hex

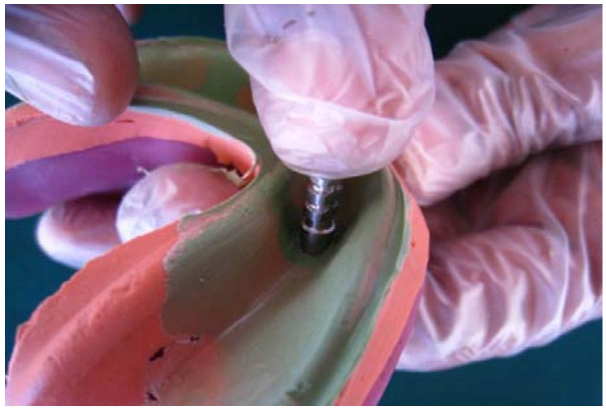


Fig. 63 Implant analogue fixed in position over the hex of direct impression coping for open tray internal hex

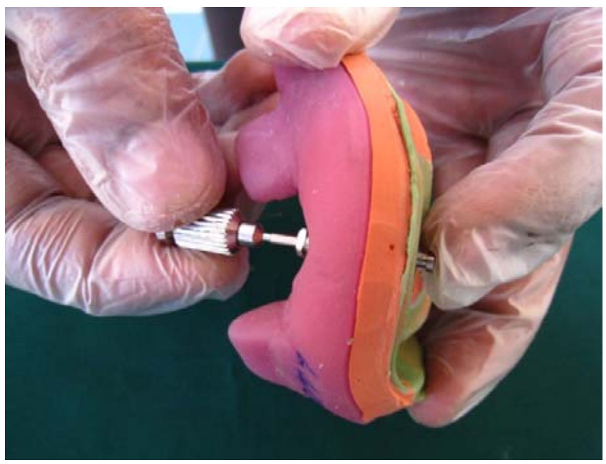


Fig. 64 Implant analogue - direct impression coping for open tray internal hex complex tightened together with fixation screw and hex driver

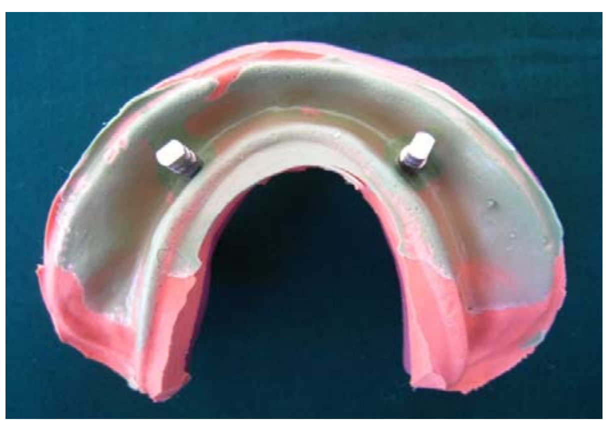


Fig. 65 Analogues in position on the impression

Fig. 66 Open tray impressions

Fig. 67 Debubbliser sprayed over the impression before pouring the cast

Fig. 68 Impression poured & inverted over the base former

Fig. 69 Impression removed from the set cast by unscrewing the fixation screws using hex driver

Fig. 70 Finished & numbered casts of open tray impressions

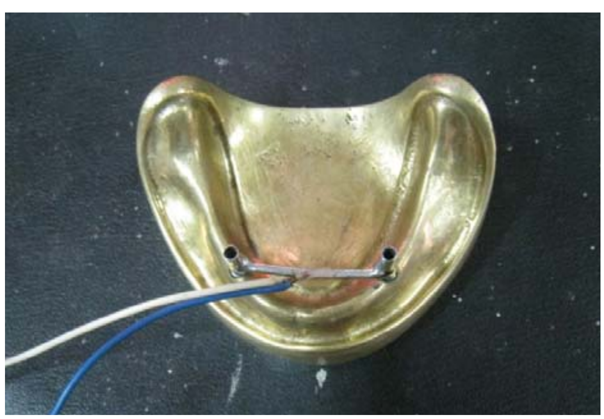


Fig. 71 Bar fixed in master model with strain gage attached

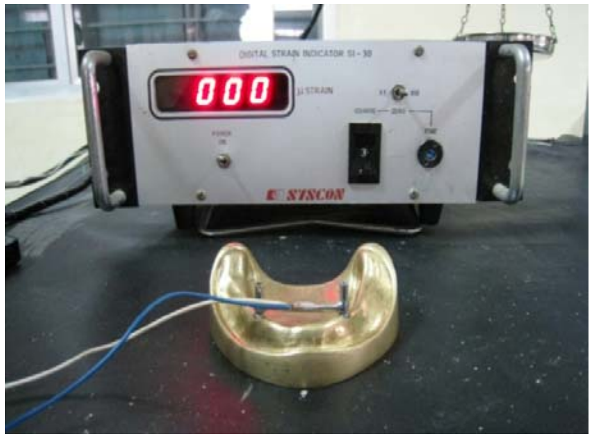


Fig. 72 Master model with bar assembly connectad to strain gage

Fig. 73 Strain value display in microstrains

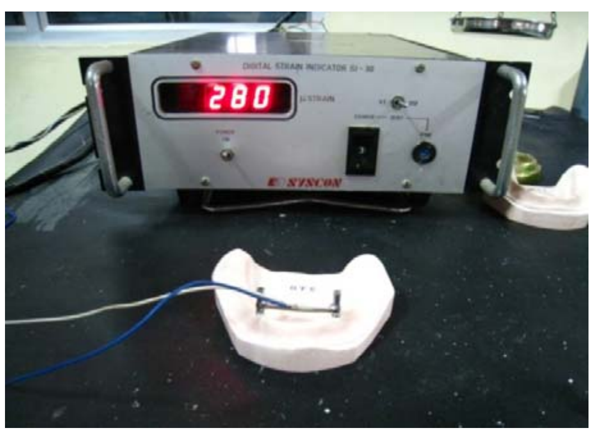


Fig. 74 Bar with strain gauge fixed in open tray sample cast

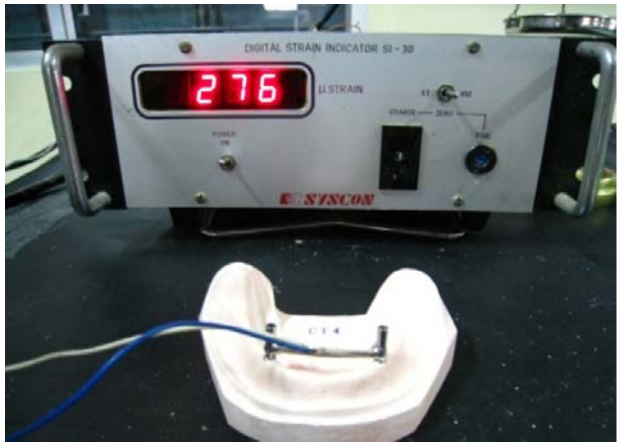


Fig. 75 Bar with strain gauge fixed in closed tray sample cast

Fig. 76 Coordinate measuring machine – TESA Micro Hite 3D

Fig. 77 X,Y,Z coordinates of Coordinate Measuring Machine

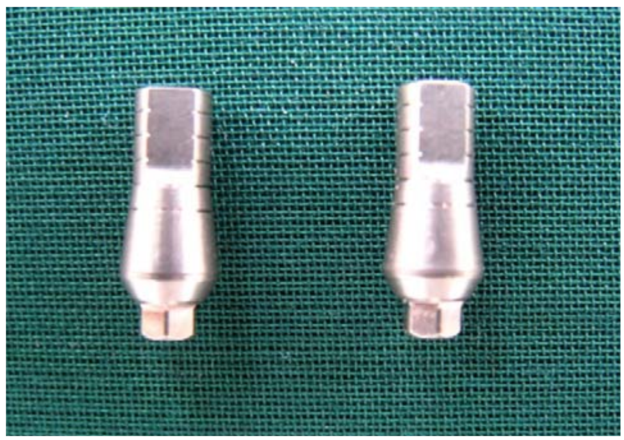


Fig. 78 Standard abutments for Coordinate analysis of implants

Fig. 79 Measuring coordinates of the abutments fixed on the Master model

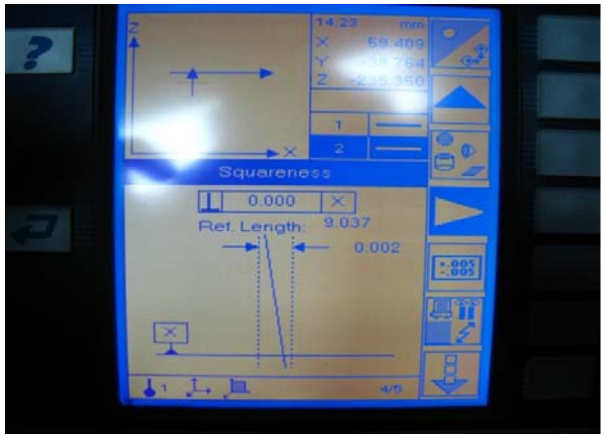


Fig. 80 Digital display of measured coordinates

Fig. 81 Measuring coordinates on the open tray cast

Fig. 82 Measuring coordinates on the closed tray cast

RESULTS

RESULTS

An invitro study was conducted to evaluate the accuracy of casts obtained with closed tray & open tray techniques. The evaluation was done using the strain gage comparing the change in strain value made with closed & open tray impression techniques and coordinate measuring machine to compare the change in coordinates of abutments fitted over casts made with closed & open tray impression techniques. Ten samples from each group were evaluated . Strain values and coordinates were tabulated for all samples. Statistical comparisons were made using One way ANOVA and Mann Whitney tests.

The basic data of the results obtained in these investigations are presented in Tables I, II, III

Table I shows the values of strain gage obtained for 10 samples of each group after screwing the bar with attached strain gage. The closed tray samples are coded as CT 1 to CT 10 and open tray samples are coded as OT 1 to OT 10.The strain values are denoted in microstrain units. Within the closed tray samples CT 1 shows the highest amount of strain 518 µstrains and the lowest is CT 2 (275 µstrains). Among the open tray samples OT 5 shows the maximum strain value of 280 µstrains and OT 4 shows the minimum strain value of 85 µstrains.

The mean of strain values for closed tray samples is 358.8 µstrains and for open tray samples is 151.5 µstrains. Hence the open tray samples show the minimum strain value of the two groups compared.

Table II shows the values for the closed tray samples obtained with coordinate measuring machine. The x axis distance (in mm) between the center points of abutments at 35 & 45 positions and their differences from the master model values, y axis values (in mm) for abutments at 35 and 45 positions are tabulated separate and their difference from the master model values are denoted on their side columns. Same way the angularity of the abutments in 35 and 45 positions are tabulated in degrees and their corresponding radian values are also tabulated for the ease of statistical analysis.

Table III shows the values for the open tray samples obtained with coordinate measuring machine. The x axis distance (in mm) between the center points of abutments at 35 & 45 positions and their differences from the master model values, y axis values (in mm) for abutments at 35 and 45 positions are tabulated separate and their difference from the master model values are denoted on their side columns. Same way the angularity of the abutments in 35 and 45 positions are tabulated in degrees and their corresponding radian values are also tabulated for the ease of statistical analysis.

Among the specimen casts ,

OT – 4 and C – 7 showed the nearest value for master model X –axis distance

OT – 1 and CT – 7 showed nearest values for master model Y – axis dimension at 35 position.

OT – 5 and CT – 1, CT -5 showed nearest values for master model Y – axis dimension at 45 position.

OT – 7 and CT – 5 showed nearest values for master model abutment angularity at 35 position.

OT – 8 and CT – 4 showed nearest values for master model abutment angularity at 45 position.

The mean value of open tray technique is closer to master model value of 27.21mm. Hence the open tray technique has the least amount of distortion in x axis direction among the two techniques.

The mean value of y axis values(in mm) of abutment at 35 position for closed tray impression casts is 8.654 mm and mean value for open tray impression casts is 9.100 mm. The mean value of open tray technique is close to the master model value of 9.115 mm.

The mean value of y axis values(in mm) of abutment at 45 position for closed tray impression casts is 8.592 mm and mean value for open tray impression casts is 8.79 mm. The mean value of open tray technique is close to the master model value of 8.965 mm.

Hence the open tray technique has the least amount of variation from master model value in y axis direction among the two techniques.

The mean value of angularity (in radians) of abutments in 35 position of closed tray technique casts is 0.09172 and that of open tray technique casts is 0.08298 which is close to the master model value of 0.08472 . Similarly the mean value of angularity values (in radians) of abutments in 45 position for closed tray impression casts is 0.07925 and that of open tray technique casts is 0.07452 which is close to the master model value.

TABLES

TABLE OF READINGS

Table I. Strain Gage Values for sample casts

Model Codes Closed tray technique CT	Strain Values (Microstrain)	Model Codes Open Tray technique OT	Strain Values (Microstrain)
CT 1	518	OT 1	182
CT 2	275	OT 2	98
CT 3	308	OT 3	210
CT 4	276	OT 4	85
CT 5	285	OT 5	280
CT 6	386	OT 6	126
CT 7	439	OT 7	148
CT 8	379	OT 8	133
CT 9	282	OT 9	120
CT 10	440	OT 10	133

*Master model strain value – 0

Table II. X , Y Coordinates and angularity of abutments at 35 & 45 positions of closed tray specimens

Closed Tray Technique									
		Y- axis (mm)				Angle (Degrees)			
X-axis	Diff	35	Diff	45	Diff	35	Radians	45	Radians
26.791	0.422	8.657	0.458	8.875	0.09	4°33'27"	0.073798	4°13'42"	0.073798
26.782	0.431	8.601	0.514	8.77	0.195	5°51'12"	0.10216	5°15'48"	0.091862
26.696	0.517	8.624	0.491	8.74	0.225	4°49'01"	0.084072	4°13'42"	0.073798
26.688	0.525	8.683	0.432	7.79	1.175	4°36'31"	0.080435	4°13'39"	0.073784
26.634	0.579	8.579	0.536	8.874	0.091	4°10'47"	0.07295	4°14'11"	0.073939
26.756	0.457	8.695	0.42	8.76	0.205	4°45'41"	0.083102	4°13'40"	0.073789
26.799	0.414	8.759	0.356	8.81	0.155	6°22'45"	0.111337	5°16'54"	0.092182
26.769	0.444	8.698	0.417	8.77	0.195	6°29'18"	0.113243	4°13'41"	0.073793
26.673	0.54	8.524	0.591	8.74	0.225	6°47'40"	0.118585	5°15'28"	0.091766
26.714	0.499	8.723	0.392	7.8	1.165	4°26'41"	0.077575	4°13'42"	0.073798
27.213		9.115		8.965		4°51'16"		4°30'86"	

Values in red colour at base of table – Master model values

Table III. X , Y Coordinates and angularity of abutments at 35 & 45 positions of open tray specimens.

Open Tray Technique									
		Y- axis (mm)				Angle (Degrees)			
X- axis (mm)	Diff	35	Diff	45	Diff	35	Radians	45	Radians
27.112	0.101	9.112	0.003	8.91	0.055	4°45'12"	0.082961	4° 11' 58"	0.073296
27.088	0.125	9.01	0.105	8.544	0.421	4°38'40"	0.081061	4° 10' 53"	0.072981
26.983	0.23	9.028	0.087	8.6105	0.3545	4°55'30"	0.085957	4° 21' 9"	0.075967
27.201	0.012	9.218	-0.103	8.677	0.288	4°40'32"	0.081604	4° 13' 2"	0.073602
27.003	0.21	9.303	-0.188	8.943	0.022	4°56'37"	0.084537	5.52'23"	0.074357
26.901	0.312	9.031	0.084	8.8765	0.0885	5°28'46"	0.095634	5° 8' 10"	0.089641
26.944	0.269	9.055	0.06	9.037	-0.072	4°17'55"	0.075025	5.30"50"	0.069505
27.189	0.024	9.052	0.063	8.7435	0.2215	4°20'48"	0.075864	3° 55' 42"	0.068564
27.182	0.031	9.098	0.017	8.677	0.288	4°50'28"	0.084493	4° 17' 38"	0.074943
26.991	0.222	9.101	0.014	8.928	0.037	4°44'26"	0.082738	4° 8' 49"	0.072378
27.213		9.115		8.965		4°51'16"		4°30'86"	

Values in red colour at base of table – Master model values

Statistical Analysis

One way ANOVA analysis for X axis values of sample casts

Null Hypothesis: There is no significant difference between the x axis values of close tray technique and open tray technique when comparing with the master model.

Xaxis

Table IV. One way ANOVA analysis for X axis values of sample casts

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	0.542	1	0.542	71.407	.000
Within Groups	0.137	18	0.008		
Total	**.678**	**19**			

Since the computed value of F (71.407) is greater than the critical value, the null hypothesis is rejected and it is concluded that there is significant difference between the close tray technique and open tray technique.

Mann Whitney Test for Y – axis values at 35 position

Null hypothesis: Median 1=155 and Median 2 = 55

Y – axis Ranks

Table V. Ranks for the sample groups

	Tray type	**N**	**Mean Rank**	**Sum of Ranks**
Yaxis-35	1.00	10	15.50	155.00
	2.00	10	5.50	55.00
	Total	**20**		

Test Statistics (b)

Table VI. Mann – Whitney analysis for Y – axis values at 35 position

	Yaxis-35
Mann-Whitney U	0.000
Wilcoxon W	55.000
Z	-3.780
Asymp. Sig. (2-tailed)	0.000
Exact Sig. [2*(1-tailed Sig.)]	0.000(a)

a. Not corrected for ties.

b. Grouping Variable: Tray type

Since Wilcoxon W value(55.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann – Whitney analysis for Y – axis values at 45 position

Ranks

Table VII. Ranks for the sample groups

	Tray type	N	Mean Rank	Sum of Ranks
Yaxis-45	1.00	10	11.70	117.00
	2.00	10	9.30	93.00
	Total	**20**		

Test Statistics (b)

Table VII. Mann – Whitney analysis for Y – axis values at 45 position

	Yaxis-45
Mann-Whitney U	38.000
Wilcoxon W	93.000
Z	-.908
Asymp. Sig. (2-tailed)	.364
Exact Sig. [2*(1-tailed Sig.)]	.393(a)

a. Not corrected for ties.

b. Grouping Variable: Tray type

Since Wilcoxon W value (93.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann – Whitney analysis for angularity values at 35 position

Ranks

Table IX. Ranks for the sample groups

	Tray type	**N**	**Mean Rank**	**Sum of Ranks**
Radians-35	Closed	10	11.10	111.00
	Open	10	9.90	99.00
	Total	**20**		

Test Statistics (b)

Table X. Mann – Whitney analysis for angularity values at 35 position

	Radians-35
Mann-Whitney U	44.000
Wilcoxon W	99.000
Z	-.454
Asymp. Sig. (2-tailed)	.650
Exact Sig. [2*(1-tailed Sig.)]	.684(a)

a Not corrected for ties.

b Grouping Variable: Tray type

Since Wilcoxon W value (99.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann – Whitney analysis for angularity values at 45 position

Ranks

Table XI. Ranks for the sample groups

	Tray type	N	Mean Rank	Sum of Ranks
Radians-45	Closed	10	12.70	127.00
	Open	10	8.30	83.00
	Total	**20**		

Test Statistics (b)

Table XII. Mann – Whitney analysis for angularity values at 45 position

	Radians-45
Mann-Whitney U	28.000
Wilcoxon W	83.000
Z	-1.666
Asymp. Sig. (2-tailed)	0.096
Exact Sig. [2*(1-tailed Sig.)]	0.105(a)

a Not corrected for ties

b Grouping Variable: Tray type

Since Wilcoxon W value (83.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann-Whitney Test – for strain gage values

Ranks

Table XIII. Ranks for the sample groups

	Strain tray	**N**	**Mean Rank**	**Sum of Ranks**
Strain values	Closed	10	15.30	153.00
	Open	10	5.70	57.00
	Total	**20**		

Test Statistics (b)

Table XIV. Mann – Whitney analysis for strain gage values

	Strain values
Mann-Whitney U	2.000
Wilcoxon W	57.000
Z	-3.630
Asymp. Sig. (2-tailed)	0.000
Exact Sig. [2*(1-tailed Sig.)]	0.000(a)

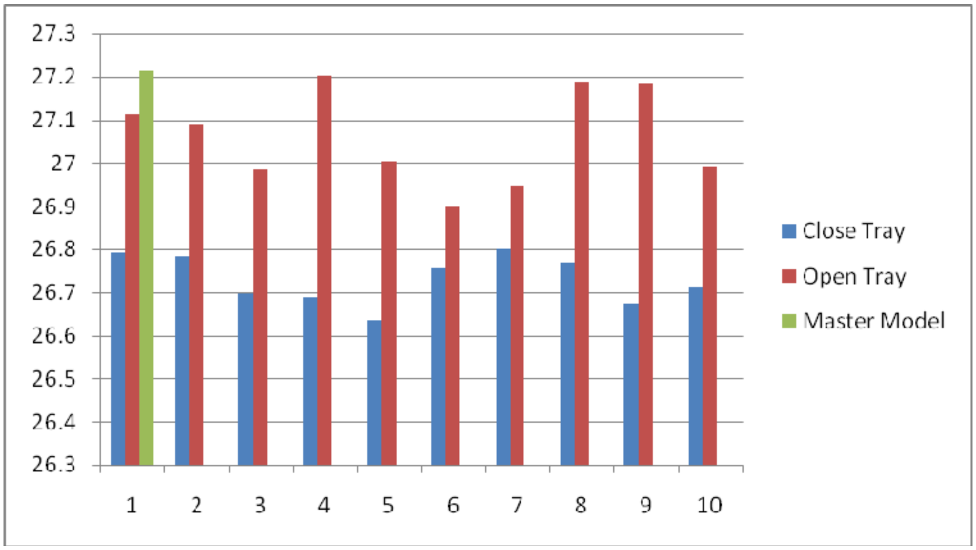
a Not corrected for ties.

b Grouping Variable: Strain tray

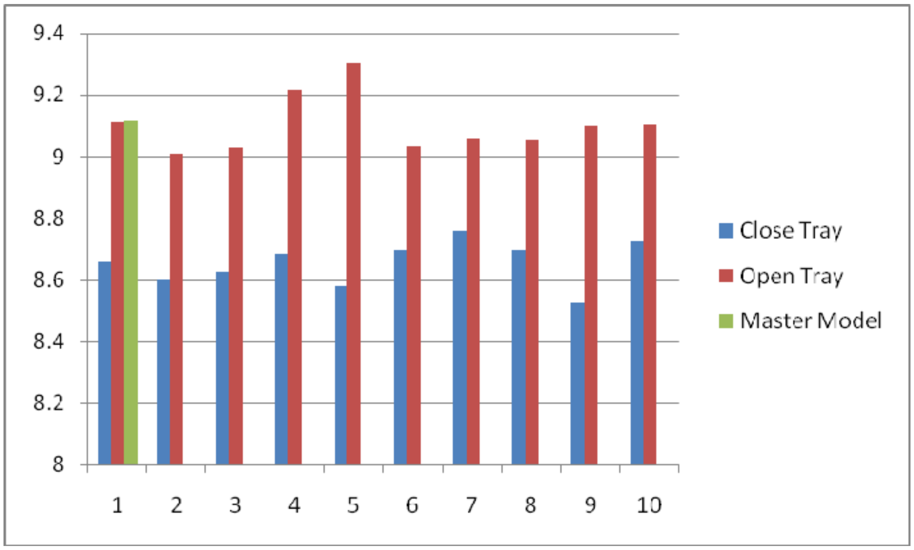
Since Wilcoxon W value (57.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

GRAPHS

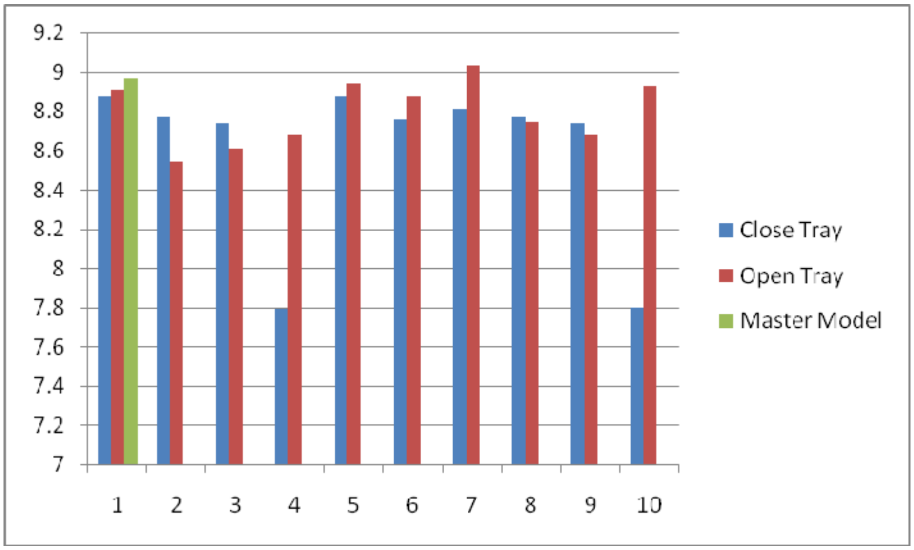
GRAPHS



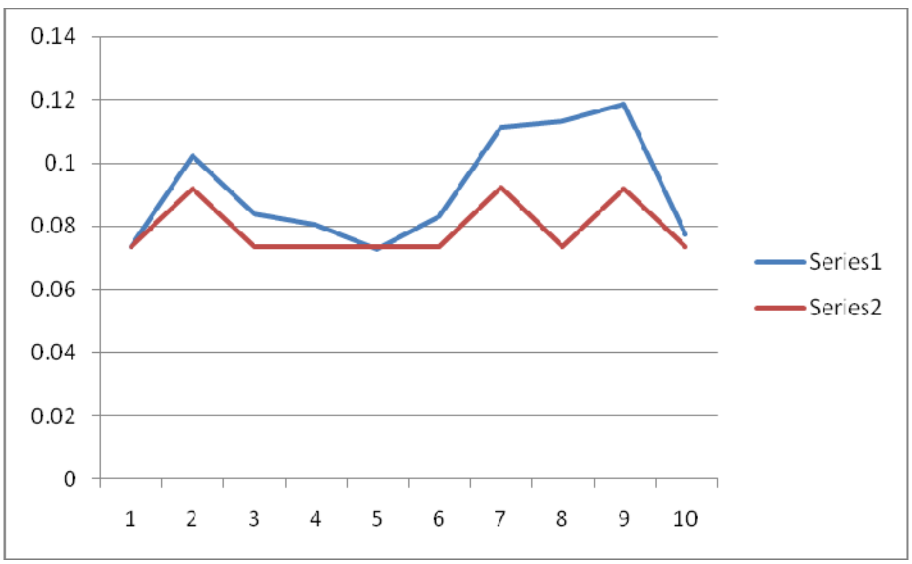
Graph I. Graph showing X axis values (Close Tray, Open Tray and Master Model Values)



Graph II. Graph showing Y axis values at 35 (Close Tray, Open Tray and Master Model Values)

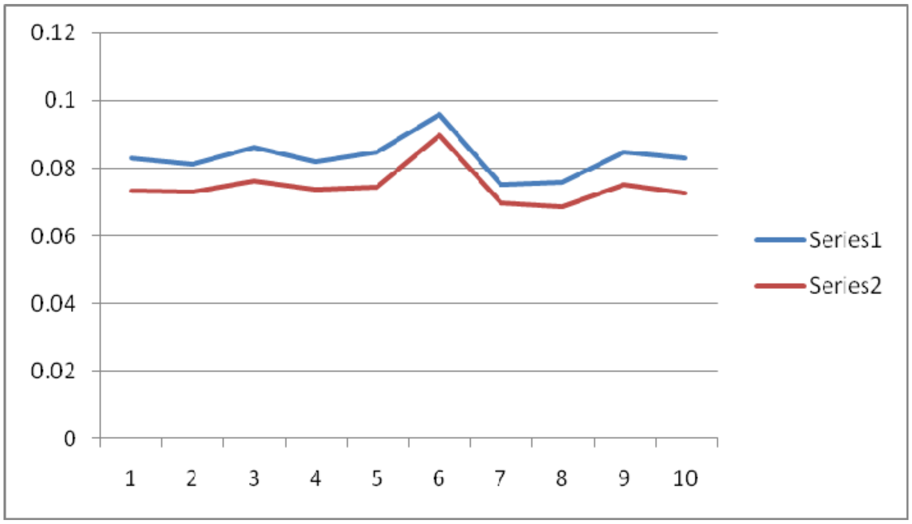


Graph III. Graph showing Y axis values at 45 (Close Tray, Open Tray and Master Model Values)



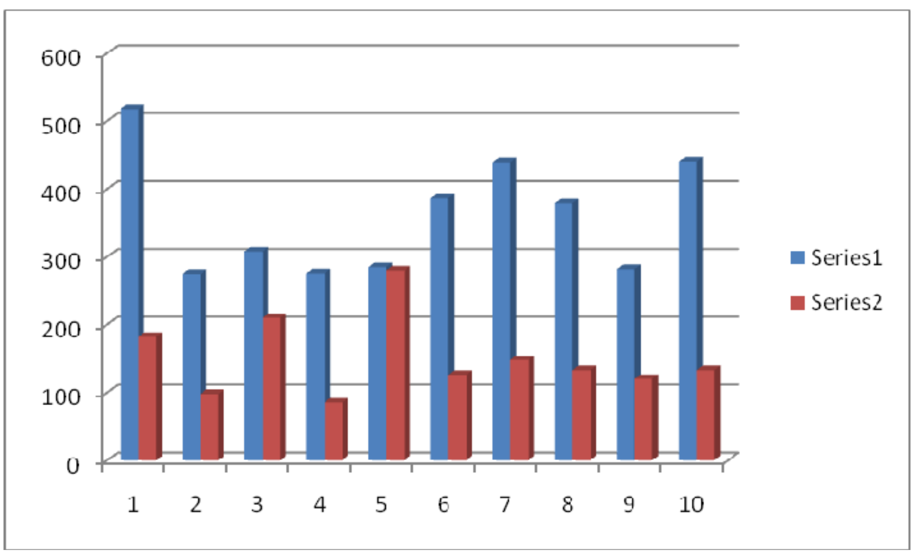
Series 1 – 35 position; Series 2 – 45 position

Graph IV. Closed Tray Angular Difference



Series 1 – 35 position; Series 2 – 45 position

Graph V. Open Tray Angular Difference



Series 1 – Closed tray values ; Series 2 – Open tray values

Graph VI. Strain Gage values (in µ-strains) for Closed tray & Open tray techniques

DISCUSSION

DISCUSSION

The process of osseointegration is a time dependent procedure [25]. The end result of this procedure is a very strong interface between the bone and implant. It is due to the unique property of the bone to remodel in accordance with the imposed functional load. If the implant is overloaded this process is compromised and a poorly differentiated interface will result which will ultimately lead to the failure of the implant [25]. Thus a proper osseointegrated prosthesis will have a good retention and stability, aesthetics, improved function, better patient comfort [25]. Osseointegration is defined as a process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved and maintained during functional loading[45]. Such stable bone implants have an interface that mainly consists of bony tissue. It differs from the natural dentition, where the teeth are anchored to the surrounding bone by means of a highly differentiated connective tissue ,the periodontal ligament [25]. The bond acting over an osseointegrated implant is a biomechanical one. This means that bone will grow in to surface irregularities of the implants with a resultant three dimensional stabilization. Many studies were done to determine the effects of misfit of the prosthesis on the osseointegration [35,46,39,50].

Many clinicians and authors [35,46,39,50] have addressed the idea that passive fit of implant prostheses is essential for the long-term treatment success. The statistical correlation between prosthesis misfit and marginal bone level changes in maxillary implants with in vivo measurements has been examined[47].This human retrospective study by David assif et al [13] found that although none of the prostheses were passively fitting, no evidence of bone loss was present even after 5 years. One of the conclusions from this study was that there must be a range of prosthesis misfit tolerated by osseointegrated implants that allows for long-term stability. Work supporting this theory has found that clinically well-fitting prostheses produced a considerable amount of misfit load but no loss of osseointegration. Though the prosthesis misfit may not affect osseointegration, there is evidence that prosthesis misfit is likely to increase the incidence of mechanical component loosening or fracture[9]. The causes of component failure and loosening are multifactorial, but it must be assumed that prosthesis misfit plays an important role in complications such as occlusal and abutment screw loosening and fracture in linked implant restorations. Because of these concerns, prosthesis misfit should be minimized. This signifies the importance of the accuracy of the impression techniques & materials employed in implant supported restorations.

In the past though many studies were done comparing the closed tray indirect transfer /open tray direct transfer impression techniques [3,4,47] , stock closed tray vs custom open trays [52] , Impression materials (Vinyl polysiloxane vs Polyether) [7]and splinted vs non splinted transfer techniques [27,32,42,48,50, 62,80] but not much literature is available comparing the direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique. The present study compares the direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique made with a single impression material (Vinyl Polysiloxane). A single impression material was chosen for the study as the main attention was on the accuracy of transfer technique rather than the material accuracy. Vinyl polysiloxane was chosen as the material exhibits good resistance to permanent deformation[11], good flexibility[11] and is most commonly used in day to day clinical practice.

This study aims at comparing the accuracy of the casts obtained with closed tray (Indirect transfer) impression technique and the open tray (Direct transfer) impression technique. A model was created with provisions to fix implant fixtures. The implant fixtures with the model, forms the base for the study. Impressions of the model was made with various implant impression techniques . Casts obtained from the impressions were assessed for accuracy using strain gauges and coordinate measuring machine (C.M.M) and statistically analysed.

Strain Gage

In the study the strain gauge is attached to the cast bar in the middle of it and the output is connected to the strain gage which interprets the strain value in microstrain.The bar was cut and laser welded after fabrication for strain free fit in the master model as per the studies done by Stephen J. Riedy et al [102.] The bar is fitted on the master model and tightened with fixation screws and hand wrench (Torque at 10 Ncm). The strain value is noted down (0 microstrain). Then the bar is fitted on the samples. The resultant strain on seating the constructed bar on the sample casts of two different techniques are tabulated. (Table. I) Strain gage was selected for this study instead of other methods like travelling microscope [3,52] or reflex microscope[48] because there is a component of operator error in the measurement with these instruments which is ruled out in the case of strain gage.

Coordinate Measuring Machine (C.M.M)

Measurement accuracy and precision improved dramatically with the invention of the electronic touch trigger probe incorporated C.M.M. The pioneer of this new probe device was David McMurtry. It is a contact device, the probe has a spring loaded ruby ball stylus. As the probe touched the surface of the component the stylus deflects and simultaneously sends the X.Y,Z coordinate information to the computer. The C.M.M used in this study is of the above said type. The X,Y coordinates and angularity of the standard abutments fitted to implants in the master model (with torque of 10 Ncm) and to the implant analogues in the specimen casts are recorded and tabulated. (Table II, III). Coordinate measuring machine to measure three dimensional coordinates is superior to the reflex microscopes used in the previous study[48] in that the C.M.M automatically calculates the centroid point of the abutment and calculates the distance from that point unlike the reflex microscope which has to be done manually or from a point other than centroid.

The result of this study provide an indepth analysis of the advantages/ disadvantages of the open and closed tray techniques, inherent inaccuracies of them and a guidance for the implant prosthodontist for the appropriate selection of the impression technique for better success. This will eliminate the shortcomings of the impression step in the treatment thereby reduce the factors contributing to the mechanical failure of implants thus improvising the predictability of the implant prosthodontics.

The results show a wide statistically significant diversion of values of casts obtained with closed tray impression technique with snapon transfer copings from the master model values.

The values obtained from **strain gage** for master model and the specimen casts of the two groups were analysed with **Mann Whitney test**. The Wilcoxon W value (57.00) lies between the median 1 and median 2, hence it is concluded that there is a significant difference between the close tray technique and open tray technique (Table XIII, XIV). The mean of strain values for closed tray samples is 358.8 µstrains and for open tray samples is 151.5 µstrains. Hence the open tray samples show the minimum strain value of the two groups compared.

The values obtained with direct transfer open tray impression technique is close to the master model There is less strain on the bar on open tray impression casts compared with the bar on closed tray impression casts.

The values of x axis , y axis variation and angularity variation obtained with Coordinate measuring machine was analysed with **One way ANOVA test** (for x axis) and **Mann Whitney test** (for y axis variation & angularity variation) .

Value of F (71.407) is greater than the critical value for ANOVA analysis of **X axis** variation (Table IV). The mean value for x – axis distance (in mm) in closed tray technique obtained casts is 26.73mm and mean value for open tray casts is 27.05 mm. The mean value of open tray technique is closer to master model value of 27.21mm. Hence the open tray technique has the least amount of distortion in x axis direction among the two techniques.

According to **Mann Whitney** analysis, the Wilcoxon W value (55.00) for **y axis** variation **at position 35** (Table V, VI) and Wilcoxon W value (93.00) for **y axis** variation **at position 45** (Table VII, VIII) lies between the median 1 and median 2. Hence the difference between the groups is statistically significant. The mean value of y axis values(in mm) of abutment at 35 position for closed tray impression casts is 8.654 mm and mean value for open tray impression casts is 9.100 mm. The mean value of open tray technique is close to the master model value of 9.115 mm. The mean value of y axis values(in mm) of abutment at 45 position for closed tray impression casts is 8.592 mm and mean value for open tray impression casts is 8.79 mm. The mean value of open tray technique is close to the master model value of 8.965 mm. Hence the open tray technique has the least amount of distortion in y axis direction among the two techniques. Similarly the Mann Whitney test results for **angularity** variation at **35** position (Wilcoxon W value (99.00) – Table XI, X) and at **45** position (Wilcoxon W value (83.00) – Table XI, XII) lies between the median 1 and median 2 .The mean value of angularity (in radians) of abutments in 35 position of closed tray technique casts is 0.09172 and that of open tray technique casts is 0.08298 which is close to the master model value of 0.08472 Similarly the mean value of angularity values (in radians) of abutments in 45 position for closed tray impression casts is 0.07925 and that of open tray technique casts is 0.07452 which is close to the master model value of 0.07520

Hence the results show a statistically significant variation ($P < 0.001$) among both the groups (techniques) and favour the open tray impression technique to be more accurate than closed tray technique (i.e less distortion in the angularity of implants with the open tray impression technique transfer compared to the closed tray impression transfer)

The results of the study are in accordance with the studies done by Alan B. Carr [3] , Jason et al [52] , Jose et al [59], Kivanc Acka et al [63] . Alan B. Carr did a similar study comparing open tray technique and closed tray technique with closed tray impression post (without snapon transfer copings). He evaluated the accuracy of sample casts with travelling microscope and concluded that the open tray impression transfer is more accurate than the closed tray impression technique.

The results of the study correlate with the results of Kivanc Acka et al [63] in which he has compared open tray & closed tray technique with polyether impression material and closed tray impression with snapon impression copings using vinyl poly siloxane impression material (VPS) and has evaluated using coordinate measuring machine. The statistical analysis of the groups showed significant differences in the X and Y directions. But there was not a significant difference in angularity between the polyether direct and polyether indirect groups.

The inaccuracy is incorporated in the closed tray impression technique is consistent with the findings of Jorgenson[3] in that a permanent deformation was induced in an elastomeric impression material when recovering it from structures having undercuts 1.0 mm in height and depth. The transfer coping below the height of contour could easily provide such an undercut and lead to deformation. Improper alignment of the flat surface of closed tray impression post to the snap on impression coping, distortion and incomplete recovery of the vinyl polysiloxane impression material due to application of excess pressure in a direction opposite to that of flat surface while aligning them will lead to X axis and angularity variation .

The inaccuracy in y axis may be due to the improper seating of the closed tray transfer into the snapon impression coping to the full depth, or conversely excess pressure to seat which deforms the impression material with less than ideal elastic recovery. Liou et al[7] has reported that indirect impression copings donot return to their original position when replaced in vinyl poly siloxane impression. All these factors for error incorporation in the transfer process is eliminated with open tray impression technique. Also due to the less number of components involved in the transfer process the less the chance of error incorporation with the open tray impression technique.

SUMMARY AND CONCLUSION

SUMMARY

A study has been conducted to evaluate the accuracy of casts obtained from open tray and closed tray impression techniques. To conduct this study a master model was constructed by placing two endosseous root form implants in lower premolar regions on either side (35 and 45). A bar was fabricated and laser welded for strain free seating of it on the master model. This was considered as the control. Test samples were grouped into two (Closed tray and Open tray) with 10 samples in each group. Impressions were made using addition polymerizing silicone - Express STD, Putty (Class 1) and Light body (Class 3) , regular set , hydrophilic impression material , 3 M ESPE , U.S.A and casts poured with type IV - dental stone, high strength, low expansion die stone - kalrock.

Then the samples were evaluated for accuracy using two different methods with electrical resistance strain gage (SYSCON) and coordinate measuring machine (TESA Microhite 3D). On analyzing the strain values from strain gage ,the values obtained with direct transfer open tray impression technique is close to the master model. There is less strain on the bar on open tray impression casts compared with the bar on closed tray impression casts. The resulting values from coordinate measuring machine showed that the mean value for x – axis distance (in mm) of open tray technique 27.05 mm is closer to master model value of 27.21 mm. Hence the open tray technique has the least amount of distortion in x axis direction among the two techniques. The mean value of y axis values (in mm) of abutment at 35 position for open tray impression casts - 9.100 mm is close to the master model value of

9.115 mm. The mean value of y axis values(in mm) of abutment at 45 position for open tray impression casts - 8.79 mm is close to the master model value of 8.965 mm. Hence the open tray technique has the least amount of distortion in y axis direction among the two techniques. The mean value of angularity (in radians) of abutments in 35 position of open tray technique casts is 0.08298 which is close to the master model value of 0.08472 . Similarly the mean value of angularity values (in radians) of abutments in 45 position open tray technique casts is 0.07452 and is close to the master model value of 0.07520. Among the impression techniques used for obtaining the casts from master model there is significant difference in values obtained on all the three axis analysed. Hence the direct transfer impression technique gives the high accuracy of transfer of implant positions from master model to the sample casts.

CONCLUSION

From the foregoing study for evaluating the accuracy of casts obtained from various implant impression techniques following conclusions have been drawn.

The open tray impression technique for transfer of 3 dimensional implant position from master model to specimen casts using direct impression coping for open tray internal hex is more accurate than the closed tray impression technique using direct impression coping for closed tray internal hex. The open tray impression technique showed better accuracy than the closed tray technique on all the three parameters evaluated (x – axis, y – axis and angularity). This clinically implies that , more the number of components used for the impression procedure, the more the chance for inaccuracy (error) getting incorporated. Hence a direct transfer impression technique with less number of components possible ensures the high accuracy of transfer of implant positions from master cast to the laboratory cast which implies the accurate transfer of implant location from the patient to the laboratory cast.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Abbas Monzavi, and Hakimeh Siadat, Use of wax spacers for putty-wash impression of implant snap-on impression copings, J Prosthet Dent 2005; 93: 494.
2. Ali Bolouri, and Rosemarie R. Zartman, Fabrication of custom clips for bar-and-clip attachments for implant-supported overdentures, J Prosthet Dent 2006; 96: 379-80.
3. Alan B. Carr, A Comparison of Impression Techniques for a Five-lmplant Mandibular Model, International Journal of Oral and Maxillofacial Implants 1991; Vol. 6, No. 4:448 – 455.
4. Alan B. Carr, Comparison of Impression Techniques for a Two-lmplant 15-Degree Divergent Model, International Journal of Oral and Maxillofacial Implants 1992; Vol. 7, No. 4: 468 – 475.
5. Alan B. Carr et al The response of bone in primates around unloaded dental implants supporting prostheses with different levels of fit, J Prosthet dent 1996; 76: 500 – 9.
6. Ali Mirfazaelian, A transfer method for multiple cement-retained implant restorations, J Prosthet Dent 2002; 87: 692 – 4.
7. Alvin G. Wee, Comparison of impression materials for direct multi-implant impressions J Prosthet Dent 2000; 83: 323-31.
8. Amany El-Hadary and James L. Drummond, Comparative study of water sorption, solubility, and tensile bond strength of two soft lining materials J Prosthet Dent 2000; 83: 356-61.

9. Amerian D.Sones Complications with osseointegrated implants; J Prosthet Dent 1989; 62: 581- 585.
10. Anthony,Albert and Whang Clinically oriented evaluation of the accuracy of commonly used impression materials;J Prosthet Dent 1986; 56: 4-9.
11. Anusavice J.Kenneth,Science of dental materials, Tenth Edition, Saunders Publication
12. Ashish Kakar, Simplified one-step procedure for making impressions and jaw relation records of implant-supported reconstruction J Prosthet Dent 1995; 74: 314-5.
13. Assuncao,Wirley and Humberto Evaluation of Transfer impressions for osseointegrated implants at various angulations; J Implant Dent, 2004; 13(4): 358-366.
14. Badr Idris et al, Comparison of the dimensional accuracy of one- and two-step techniques with the use of putty/wash addition silicone impression materials J Prosthet Dent 1995; 74: 535-41.
15. Belinda Gregory-Head, and Eugene LaBarre, Two-step pick-up impression procedure for implant-retained overdentures J Prosthet Dent 1999; 82: 615-6.
16. Bertil Friberg, Torsten Jemt, Ulf Lekholm, Early Failures in 4,641 Consecutively Placed Brånemark Dental Implants: A Study From Stage 1 Surgery to the Connection of Completed Prostheses: International Journal of Oral and Maxillofacial Implants 1991; Vol. 6, No. 2: 142 – 146.
17. Bi-Yuan Tsai Use of provisional restorations as implant impression copings J Prosthet Dent 2007; 97: 395-396.

18. Branemark Osseointegration and its experimental background; J prosthet dent1981; 50: 399-410.

19. Brent L. Beyak, and Winston W. L. Chee, Compatibility of elastomeric impression materials for use as soft tissue casts J Prosthet Dent 1996; 76: 510 – 4.

20. Brian Myung W. Chang et al, A solid bar splint for open-tray implant impression technique, J Prosthet Dent 2006; 96: 143 – 4.

21. Bo Rangert et al Forces and Moments on Brånemark Implants, International Journal of Oral and Maxillofacial Implants 1989; Vol. 4, No. 3: 241 – 247.

22. Bulent Uludag, and Gozde Celik, An alternative impression technique for implant-retained overdentures, J Prosthet Dent 2006; 96: 377-8.

23. Buluent Uludag and Volkan Sahin A functional Impression technique for an implant supported overdenture; J oral Implant. 2006; 23: 41-43.

24. Cabral, Leonardo and Carlos Comparative analysis of 4 impression techniques for implants, J Implant Dent 2007; 16(2): 187-194.

25. Carl E Misch. Contemporary implant dentistry 3 rd ed. 1999, Mosby Publishers, Baltimore

26. Chee and Jivraj Impression techniques for implant dentistry; British Dental Journal, 2006; 201: 429-432.

27. Chii-Chih Hsu, Philip and Sheldon comparative analysis of the accuracy of implant transfer techniques; J Prosthet dent 1993; 69: 588-593.

28. Cox J.F., Zarb, The Longitudinal Clinical Efficacy of Osseointegrated Dental Implants: A 3-Year Report, International Journal of Oral and Maxillofacial Implants 1987; Vol. 2, No. 2: 91 – 100.

29. Dan E. Tolman, William R. Laney, Tissue-lntegrated Prosthesis Complications International Journal of Oral and Maxillofacial Implants 1992; Vol. 7, No. 4: 477 – 484.

30. Daniel Y. Sullivan, Prosthetic Considerations for the Utilization of Osseointegrated Fixtures in the Partially Edentulous Arch, International Journal of Oral and Maxillofacial Implants 1986; Vol. 1, No. 1: 39 – 45.

31. David Assif,Barry and Joseph Modified impression technique for implant supported restoration; J Prosthet dent 1994; 71: 589-591.

32. David Assif et al Accuracy of Implant Impression Techniques, International Journal of Oral and Maxillofacial Implants 1996; Vol. 11, No. 2: 216 – 222.

33. David Assif et al Accuracy of Implant Impression Splinted Techniques:Effect of Splinting Material International Journal of Oral and Maxillofacial Implants 1999; 14: 885–888.

34. David A. Kaiser, and John D. Jones, New impression system for ITI solid abutment cementable restoration J Prosthet Dent 2000; 83: 276-8.

35. David M. Davis et al, Studies on Frameworks for Osseointegrated Prostheses: Part 1. The Effect of Varying the Number of Supporting Abutments, International Journal of Oral and Maxillofacial Implants 1988; Vol. 3, No. 3: 197 – 201.

36. David R. Frederick, The provisional fixed partial denture, J Prosthet Dent; Vol 34, No 5: 520 – 527.

37. Eames et al, Elastomeric impression materials: Effect of bulk on Accuracy, J Prosthet dent March 1979; Vol 41, No 3: 304 -308.

38. Emad El Haje, Direct impression coping for an implant system, J Prosthet Dent 1995; 74: 434-5.

39. Eric J. Rasmussen Alternative prosthodontic technique for tissue integrated prosthesis, J Prosthet Dent 1987; 57:198 -203.

40. Eugene E. Keller et al, Surgical-Prosthodontic Reconstruction of Advanced Maxillary Bone Compromise with Autogenous Onlay Block Bone Grafts and Osseointegrated Endosseous Implants: A 12-Year Study of 32 Consecutive Patients, International Journal of Oral and Maxillofacial Implants 1999; 14: 197–209.

41. Francis S.Tautin, Impression making for osseointegrated implants, J Prosthet Dent,1985; 54: 250-251.

42. Gamal Burawi et al, A comparision of the dimensional accuracy of the splinted and unsplinted impression techniques for the bone – lock implant system, J Prosthet Dent,1997; 77: 68-75.

43. George C. Cho et al, Tensile bond strength of polyvinyl siloxane impressions bonded to a custom tray as a function of drying time: Part I, J Prosthet Dent 1995; 73: 419-23.

44. George C. Cho, and Winston W.L. Chee, Efficient soldering index materials for fixed partial dentures and implant substructures, J Prosthet Dent 1995; 73: 424-7.

45. Glossary of Prosthodontic terms.8th Edition 2005.

46. Gregow A. Waskewicz et al, Photoelastic analysis of stress distribution transmitted from a fixed prosthesis attached to osseointegrated implants,

International Journal of Oral and Maxillofacial Implants 1994; Vol. 9, No. 4: 405 – 411.

47. Heather J. Conrad et al, Accuracy of two impression techniques with angulated implants, J Prosthet Dent 2007; 97: 349-356.
48. Herbst D, et al, Evaluation of impression accuracy for osseointegrated implant supported Superstructures, J Prosthet Dent 2000; 83: 555-61.
49. Hobkirk J. A., and J. Schwab, Mandibular Deformation in Subjects With Osseointegrated Implants: International Journal of Oral and Maxillofacial Implants 1991; Vol. 6, No. 3: 319 – 328.
50. Humphries and Bloem The accuracy of implant master casts fabricated for transfer impressions, International Journal of Oral and Maxillofacial Implants,1990; 5: 331-336.
51. James E. and Fonda G. Robinson Simplified impression technique for implant supported crowns, Dental Clinics of North America 2006; 50: 439-449.
52. Jason Burns et al Accuracy of open tray implant impressions: an in vitro comparison of stock versus custom trays J Prosthet Dent 2003; 89: 250-5.
53. Jeffrey L. Shotwell, et.al Proceedings of a Consensus Conference on Implantology October 18, 1989, Mainz, West Germany, International Journal of Oral and Maxillofacial Implants 1990; Vol. 5, No 2: 182 – 187..
54. Jiunn-chin and Ling An accurate impression method for implant prosthesis fabrication; J Prosthet Dent 1994; 72: 23-25.
55. John D. Jones, and David A. Kaiser A new gingival retraction impression system for a one-stage root-form implant; J Prosthet Dent 1988: 80: 370-373.

56. John R.Ivanhoe An impression Technique for osseo integrated Oral implants J Prosthet Dent 1991: 66: 410-411.

57. John W.McCartney and Rozier Pearson Segmental framework matrix: Master cast verification, corrected cast guide, and analog transfer template for implant suppored prosthesis; J Prosthet Dent 2003: 71: 197.

58. Jorge E. De La Cruz et al Verification jig for implant-supported prostheses: A comparison of standard impressions with verification jigs made of different materials J Prosthet Dent 2002; 88: 329-36.

59. Jose,Steven and Jeffrey Evaluation of three impression techniques for osseointegrated oral implants; J Prosthet dent 1993: 69; 503-509.

60. Judson Klooster,Irving and Anthony Effects of strain rate on the behaviour of elasomeric impression; J Prosthet Dent 1991; 66: 292-298.

61. Joseph Nissan et al Impression technique for partially edentulous patients J Prosthet Dent 2002; 88: 103-4.

62. Keith M. Phillips et al The Accuracy of Three Implant Impression Techniques: A Three-dimensional Analysis, International Journal of Oral and Maxillofacial Implants 1994; Vol. 9, No. 5: 533 – 540.

63. Kivanc et al, Murat C Cehreli Accuracy of two impression techniques for ITI implants, International Journal of Oral and Maxillofacial Implants 1999; 14: 885–888.

64. Kıvanç Akça et al A surgical guide for accurate mesiodistal paralleling of implants in the posterior edentulous mandible J Prosthet Dent 2002; 87: 233-5.

65. Konstantinos X. Michalakis et al A simple impression technique for dental implants placed in close proximity or adverse angulations J Prosthet Dent 2005; 94: 293-5.
66. Larry A fixed prosthodontic technique for mandibular osseointegrated titanium implants; J Prosthet Dent 1986; 55: 232 -242.
67. Leonard B.Shulman,Thomas and Michael S.Block Dental implants:Historical Perspective –Implants in dentistry
68. Linke B. A, J.I.Nicholls and R.R.Faucher Distortion analysis of stone casts made from impression materials; J Prosthet Dent 1985; 54: 794-802.
69. Mariano A.Polack Simple method of fabricating an impression coping to reproduce peri implant gingiva on the master cast; J Prosthet dent 2002; 88: 392-396.
70. Marianna Pasciuta et al A prosthetic solution to restoring the edentulous mandible with limited interarch space using an implant-tissue-supported overdenture: A clinical report, J Prosthet Dent 2005; 93: 116-20.
71. Mark R.Spector,Terry and Jack An evaluationof impression techniques for osseointgratd implants; J Prosthet Dent 1990; 63: 444-447.
72. Michael Wise, Fit of implant-supported fixed prostheses fabricated on master casts made from a dental stone and a dental plaster, J Prosthet Dent 2001; 86: 532-8.
73. Murat Cehreli and Kivanc, Impression techniques and misfit induced strains on implant spported superstructures:An invitro study, J Prosthet Dent 2006; 26: 379-85.

74. Naert .I, Quirynen .M and D.Van steenberghe Prosthetic aspects of osseointegrated fixtures supporting overdentures; J Prosthet Dent 1991; 65: 671-680.

75. Nicolas Eid An implant impression technique using a plaster splintng index combined with a silicone impression; J Prosthet Dent 2004; 92: 575-577.

76. Nopsaran Chaimattayompol Nancy S. Arbree, and Stefanie X. Wong, A simple method of making an implant level impression when presented with limited space, unfavourable implant positions or problematic implant angulations; J Prosthet dent 2002; 87: 684-687.

77. Nopsaran Chaimattayompol, Chairside fabrication of provisional implant-supported prosthesis using impression copings; J Prosthet dent 2000; 83: 374-375.

78. Omid Savabi and Farhanz Custom impression tray for dental implants; J Prosthet Dent 2007; 97:183-184.

79. Paolo Vigolo, Philip L. Millstein, Evaluation of Master Cast Techniques for Multiple Abutment Implant Prostheses, International Journal of Oral and Maxillofacial Implants, 1993; Vol. 8, No. 4: 439 – 445.

80. Paolo Vigolo, Zeina Majzoub, and Giampiero Cordioli, Evaluation of the accuracy of three techniques used for multiple implant abutment impressions J Prosthet Dent 2003; 89: 186-92.

81. Paolo Vigolo and Maizoub An evaluation of impression techniques for multiple internal connection implant prosthesis; J Prosthet Dent 2004; 92: 470-476.

82. Paolo Vigolo et al Master cast accuracy in single implant replacement cases; an invitro comparison,a technical note, International Journal of Oral and Maxillofacial Implants, 2005; 20: 455-460.

83. Patrick J.Henry An alternative method for the production of accurate casts and occlusal records in osseoinegrated implant rehabilitation;J Prosthet Dent 1987; 58: 694-697.

84. Patrick J. Henry, Albert E. S. Tan, and Shinobu Uzawa, Fit discrimination of implant-supported fixed partial dentures fabricated from implant level impressions made at stage I surgery; J Prosthet Dent 1997; 77: 265-270.

85. Patrick J Stevens. Implant Prosthodontics- Clinical and laboratory procedures. 2000, Mosby Inc. USA

86. Philip Worthington et al The Swedish System of Osseointegrated Implants: Problems and Complications Encountered During a 4-Year Trial Period, International Journal of Oral and Maxillofacial Implants, 1987; Vol. 2, No. 2: 77 – 84.

87. Patten and M.Novetsky Detail reproduction of soft tissue:A comparison of impression materials; J Prosthet Dent 1991; 65: 188-191.

88. Ragnar Adell et al A Long-Term Follow-up Study of Osseointegrated Implants in the Treatment of Totally Edentulous Jaws, International Journal of Oral and Maxillofacial Implants 1990; Vol. 5, No. 4: 347 – 359.

89. Rangert B, Jemt T, Jörnéus L. Forces and moments on Brånemark implants. Int J Oral Maxillofac Implants 1989; 4: 241-247.

90. Reisbiek M. H, and J. Matyas The accuracy of highly filled elastomeric impression materials, J.Prosthet Dent 1975; 33, 1: 67 – 72.

91. Richard J. Windhorn, and Thomas R. Gunnell, A simple open-tray implant impression technique J Prosthet Dent 2006; 96: 220-1.

92. Richard Skalak, Biomechanical considerations in osseointegrated prostheses J Prosthet Dent; 1983: 49, 6: 843-849.

93. Richard W. Toth et al A trayless impression technique for complete arch implant-supported immediately loaded provisional and definitive restorations J Prosthet Dent 2005; 94: 202-3.

94. Robert M. Humphries et al The Accuracy of Implant Master Casts Constructed From Transfer Impressions, International Journal of Oral and Maxillofacial Implants 1990; Vol. 5, No. 4: 331 – 336.

95. Roger A. Solow Simplified radiographic-surgical template for placement of multiple, parallel implants J Prosthet Dent 2001; 85: 26-9.

96. Rutger H. K. Batenburg et al Treatment Concept for Mandibular Overdentures Supported by Endosseous Implants:A Literature Review International Journal of Oral and Maxillofacial Implants 1998;13: 539–545.

97. Sahin S,Cehreli The significance of passive framework fit in implant prostodontics; Imp dent 2001; 10: 85-91.

98. Shiau chin and Wu chen tsye An accurate impression method for implant prosthesis fabrication; J Prosthet Dent 1994; 72: 23-25.

99. Song-Bor Kuo et al Developing an optimal emergence profile of the definitive restoration with a modified impression cap technique for ITI solid abutment J Prosthet Dent 2002; 88: 646-8.

100. Sina Jannesar, Hakimeh Siadat,and Marzieh Alikhasi, A Dual Impression Technique for Implant Overdentures J Prosthodont 2007; 16: 327-329.

101. Souheil Hussaini, and Tanya Wong, One clinical visit for a multiple implant restoration master cast fabrication J Prosthet Dent 1997; 78: 550-3.

102. Stephen I. Riedy, et al Fit of implant frameworks fabricated by different techniques J Prosthet Dent 1997; 78: 596-604.

103. Stephen M. Parel Modified Casting Technique for Osseointegrated Fixed Prosthesis Fabrication: A Preliminary Report, International Journal of Oral and Maxillofacial Implants, 1989; Vol. 4, No. 1: 33 – 40.

104. Sumiya Hobo. Osseointegration and occlusal rehabilitation. 1989, Quintessence publishing Co. Inc. Hong Kong

105. Tae-Ju Oh, Implant surgical guide fabrication for partially edentulous patients J Prosthet Dent 2005; 93: 294-7.

106. Thomas D. Taylor et al Implant Prosthodontics: Current Perspective and Future Directions International Journal of Oral & Maxillofacial Implants 2000; Vol 15, No 1: 292-296.

107. Thomas J. Emmer et al Bond strength of permanent soft denture liners bonded to the denture base J Prosthet Dent 1995; 74: 595-601.

108. Thomas Kallus, Christer Bessing, Loose Gold Screws Frequently Occur in Full-Arch Fixed Prostheses Supported by Osseointegrated Implants After 5 Years, International Journal of Oral and Maxillofacial Implants 1994; Vol. 9, No. 2: 169 – 178.

109. Torsten Jemt Failures and Complications in 391 Consecutively Inserted Fixed Prostheses Supported by Brånemark Implants in Edentulous Jaws: A Study of Treatment From the Time of Prosthesis Placement to the First Annual

Checkup, International Journal of Oral and Maxillofacial Implants 1991; Vol. 6, No. 3: 270 – 275.

110. Torsten Jemt et al In Vivo Load Measurements on Osseointegrated Implants Supporting Fixed or Removable Prostheses: A Comparative Pilot Study, International Journal of Oral and Maxillofacial Implants, 1991; Vol. 6, No. 4: 413 – 417.

111. Torsten Jemt et al Failures and Complications in 127 Consecutively Placed Fixed Partial Prostheses Supported by Brånemark Implants: From Prosthetic Treatment to First Annual Checkup, International Journal of Oral and Maxillofacial Implants 1992; Vol. 7, No. 1: 40 – 44.

112. Torsten Jemt, et al Measuring fit at the implant prosthodontic interface J Prosthet Dent; 1996; 75: 314-315.

113. Torsten Jemt In Vivo Measurements of Precision of Fit Involving Implant-Supported Prostheses in the Edentulous Jaw, International Journal of Oral and Maxillofacial Implants 1996; Vol. 11, No. 2: 151 – 158.

114. Torsten Jemt et al, A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants, Journal of Oral and Maxillofacial Implants 1996; Vol. 11, No. 3: 291 – 298.

115. Torsten Jemt, Kristian Book, Prosthesis misfit and marginal bone loss in edentulous implant patients, International Journal of Oral and Maxillofacial Implants 1996; Vol. 11, No. 5: 620 – 625.

116. Ulf Lekholm et al Survival of the Brånemark Implant in Partially Edentulous Jaws: A 10-Year retrospective Multicenter Study Int J Oral Maxillofac Implants 1999; 14: 639 – 645.

117. Walton J.N. and Macentee M.I. Problems with prostheses on implants; J Prosthet dent 1994; 71: 283-288.

118. Winston W L. Chee, and Marc L. Alexander Impression Technique for Arches Reqiuiring Both ImGlant and Natural Tooth Restorations; J Prosthodont 1998; 7: 45-48.

119. Yasuyuki Matsushita, Masafumi Kihara, A modified implant impression technique J Prosthet Dent 2002; 87: 343-4.

120. Yen-Chen Ku, Yu-Fu Shen, Fabrication of a radiographic and surgical stent for implants with a vacuum former J Prosthet Dent 2000; 83: 252-3