COMPARATIVE EVALUATION OF DIMENSIONAL ACCURACY OF DENTAL CASTS OBTAINED FROM THREE PUTTY WASH IMPRESSION TECHNIQUES AND MATRIX IMPRESSION TECHNIQUE - AN INVITRO STUDY

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CERTIFICATE

Certified that the dissertation on **"COMPARATIVE EVALUATION OF DIMENSIONAL ACCURACY OF DENTAL CASTS OBTAINED FROM THREE PUTTY WASH IMPRESSION TECHNIQUES AND MATRIX IMPRESSION TECHNIQUE - AN INVITRO STUDY"** done by **Dr.P.Ranjith Kumar,** Postgraduate student (MDS), **Branch VI Prosthetic Dentistry**, Saveetha Dental College and Hospitals, submitted to The Tamil Nadu Dr.M.G.R. Medical University in partial fulfillment for the M.D.S.degree examination in march 2006, is a bonafide dissertation work done under my guidance and supervision.

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CERTIFICATE

Certified that the dissertation on **"COMPARATIVE EVALUATION OF DIMENSIONAL ACCURACY OF DENTAL CASTS OBTAINED FROM THREE PUTTY WASH IMPRESSION TECHNIQUES AND MATRIX IMPRESSION TECHNIQUE - AN INVITRO STUDY"** done by **Dr.P.Ranjith Kumar,** Postgraduate student (MDS), **Branch VI Prosthetic Dentistry**, Saveetha Dental College and Hospitals, submitted to The Tamil Nadu Dr.M.G.R. Medical University in partial fulfillment for the M.D.S.degree examination in march 2006, is a bonafide dissertation work.

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CONTENTS

INTRODUCTION

The fixed partial prosthodontics is one of the well developed and well accepted treatment modalities in the field of Prosthodontics and their success is immensely dependent on a multitude of factors involving a high degree of precision in both clinical and laboratory procedures. Any compromise in clinical and laboratorial protocols can seriously jeopardize the outcome of a successful treatment.

After the completion of tooth preparation an accurate impression is essential for fabrication of a precise fixed partial denture. Numerous studies have been conducted to assess the efficacy of different impression materials and various impression techniques that are widely used in contemporary fixed prosthodontics. The researchers have claimed that despite tremendous advances in the impression materials, the impression technique can alter the reproduction of surface detail, there by influencing the final fit of the restoration.[25,50,51,56,66]

Among the myriad of various impression materials, there is a wide spread consensus and acceptance of addition silicon elastomers among clinicians for accurate impression making. Several techniques have been suggested to improve the accuracy of poly vinyl siloxane (PVS) impressions among clinicians. The most commonly used putty-wash impression techniques are - single step technique, putty-wash double stage technique and putty wash double stage technique with polyethylene spacer. Furthermore, the thickness of the wash material is an essential factor that influences the accuracy of elastomeric materials.[1,8,19,66]

A new system of matrix impression technique using elastomers has been reported in the literature[62] which incorporates the attributes of traditional methods and attempts to overcome the deficiencies of the older systems. This system is reported to effectively control the four determinants namely relapsing, retraction, displacement and collapsing that impact on the gingiva during the critical phase of impression making when attempting to register the sub-gingival margins.[62]

Though the putty-wash impression technique is widely used for impression making, their modifications and variations play a major role in their accuracy. Also the evolution of newer innovative techniques like the matrix impression technique in fixed prosthodontics greatly demands the proper selection of an impression technique to achieve clinical success. Hence the study was carried out,

1. to determine the accuracy of stone casts obtained from single stage putty-wash, double stage putty-wash with polyethylene spacer, double stage putty-wash with 2mm spacer and matrix impression technique.
2. to compare the values and evaluate the amount of discrepancy between various techniques.

REVIEW OF LITERATURE

Fairhurst, C.W. et al (1956)[1] studied the elastic behavior of rubber base impression materials during the setting period at various time intervals. The results showed that for most rubber base impression materials, the elastic properties improved considerably when they were allowed to set longer than recommended by the manufacturer. After proper setting, most of these materials exhibited excellent elastic properties and stability during storage for atleast twenty – four hours. Best accuracy in reproduction, particularly over long spans was obtained by a technique utilizing an individual tray of acrylic resin allowing 2 to 3 mm thickness of the impression materials.

Mitchell J.V., J.J. Damele (1970)[2] investigated the effects of the restrictive influence of the impression trays upon distortion of 4 types of elastic impression materials. The impression materials tested, included reversible and irreversible hydrocolloids and two elastomeric materials (polysulfide and silicone base). The distortion produced by shrinkage of elastic impression not restricted by the form of tray was of minimal proportion and the shrinkage of the impression towards attachment of the tray was a major contributor.

Stackhouse J.A. (1970)[3] used a laboratory method to measure the accuracy of stone dies made from four rubber base elastomers (One polysulfide and three silicones) in three clinically simulated techniques and found out that more uniform dies were produced from the silicone impression material than from the polysulfide rubber impression material. Perforated tray technique caused the stone dies to be undersized in diameter, but has less effect on die length. Two techniques (relief area and simultaneous double mix) were not significantly different from each other.

Fusayama T. et al (1974)[4] evaluated the accuracy of stone dies made from the laminated single impression technique with silicone material. They concluded that the laminated single impression techniques which is clinically simple, was found to be capable of producing stone models having adequate dimensional accuracy and sufficient surface reproducibility.

Sawyer H.F. et al (1974)[5] conducted a study to determine the comparative accuracy of stone casts produced from eight different elastomeric impression materials namely - one polysulfide, five silicones and two polyether impression materials. Each impression was permitted to set for 15 minutes without pressure at 38°C and was immediately poured in die stone, except for polyether rubber for which pouring was delayed one week after the impressions were made. The most accurate casts were produced from the polyether impression elastomers and the next most accurate from the silicone impression elastomers. The measurements of the casts produced from the impression, poured one week later, varied slightly from those poured immediately.

Stackhouse J.A. (1975)[6] investigated various brands of elastic impression materials and concluded when the die material was poured in 30 minutes, there were no significant differences in accuracy among all of the elastomers tested. The analysis also showed that the dies poured immediately from the hydrocolloids did not differ significantly from those of the other materials poured in 30 minutes. In general, the second and third generations of dies obtained from the mercaptans and silicones were significantly different from the first generations and at the end of a 24 hour period, the silicone materials had changed more rapidly than the mercaptans, and with each type, individual brands varied.

Reports of Councils and Bureaus (1977)[7] revised American Dental Association specification No.19 for non aqueous, elastomeric dental impression materials.

Eames W.B. et al (1979)[8] conducted a study to determine the effect of bulk on the accuracy of elastomeric impression materials. A stainless steel master die representing a complete crown preparation with a 12-degree taper was used. Impression trays were fabricated providing 2, 4 and 6mm spaces to determine the stability and accuracy of nine elastomeric impression materials. The results showed that the 2mm space produced the most accurate impression for all of the materials tested.

Eames W.B. et al (1979)[9] conducted a study to determine the accuracy and dimensional stability of elastomeric impression materials. 20 impression systems were used and found that the amount of contraction that all materials exhibited at 30 minutes ranged from 0.11% to 0.45%. In general, the silicones demonstrated the greatest change. At 24 hours, stability ranged from 0.18% to 0.84%. Polyethers and polysulfides were generally more stable and silicones were least stable dimensionally. The new addition reaction silicones, president and premagum exhibited the least change. They were found to be statistically equivalent to the polyether materials.

Robert J. Luebke et al (1979)[10] studied the effect of delayed and second pour on accuracy of polysulfide, silicone and polyether impression material. Results showed delay in time for pouring adversely affected silicone and polysulfide impression material. Polyether showed no difference. All materials did not differ from master die when poured within 15 mins.

Eames W.B. J.C. Sieweke (1980)[11] investigated the feasibility of the putty – wash system of impressions as an alternative to the custom made tray of acrylic resin.

Yeh C.L. J.M. Powers, R.G. Craig (1980)[12] conducted a study using commercially available addition type silicone impression materials. These materials were evaluated for their physical, mechanical and viscoelastic properties. They concluded that these materials have low dimensional change on setting, low creep, moderately short working time and are fairly stiff at the time of removal from the mouth with moderately high resistance to tear.

Brown David (1981)[13] assessed the factors, which can influence the accuracy and stability of elastomeric impression materials and the impression procedures. The result showed that, polysulfide impression materials had the greatest overall shrinkage, due to both thermal shrinkage and polymerization shrinkage. The polyether impression materials showed greatest thermal shrinkage but later when stored in damp condition, the impression showed good accuracy.

The Type I (condensation silicone) impression materials showed little shrinkage on storage. The author recommended the twin-mix impression technique or two stages without spacer impression technique for better results.

The Type II (addition silicone) was the most stable impression material. The author advocated the twin-mix and two stages with spacer impression technique for better results.

Ciesco J.N. et al (1981)[14] compared the accuracy and dimensional stability of various elastomeric impression materials used in fixed prosthodontics. Two techniques were evaluated and concluded that all impression materials that were poured immediately and evaluated using a custom tray and adhesive consistently demonstrated superior results in comparison to those tested without the custom tray. Polyether material consistently yielded superior result with or without a custom tray when compared to other impression materials. The addition polymerization silicone ranked second, followed by the lead cure polysulfide and the condensation polymerization silicone respectively.

Lacy A.M. et al (1981)[15] conducted a quantitative study to compare the accuracy and dimensional stability of one polyether, four polysulfide rubber and four polyvinylsiloxane (addition polymerization silicones). They compared the rate and magnitude of change of die size obtained from sequential pours of dental die stone in a given impression over a 4-day period. They concluded that polyvinyl siloxanes (addition polymerization) silicones are the most stable of elastomers currently available. Accuracy and consistency were best maintained by use of custom tray and adhesives to retain polyvinyl siloxanes.

Marcinak C.F., R.A. Draughn (1982)[16] conducted a study on linear dimensional changes in addition silicone impression materials. The dimensional stability of the impression materials was evaluated by measuring the size of a stone die produced from an impression of a master model and comparing the die size with the master model. The impression of the master model was stored for various periods prior to pouring. They found that there was no consistent pattern of increase or decrease in die size that occurred with time. Dies produced at 168th hour were as accurate as those produced at 10 minutes.

Sandrik J.L., J.L. Vacco (1983)[17] determined the tensile properties of putty and wash elastomeric impression materials and the strength of the bond between these materials. The impression materials used were polysulfide, condensation silicone and addition silicone. The results showed that addition reaction silicone impression materials had the greatest bond strength between materials of putty and wash consistency and the bond strength of these materials was found to be greater than the strength of the adhesive bond of the elastomer to the impression tray. Also, the bond strength of putty – wash elastomers was less than the tensile strength of the respective components except for the addition reaction silicone materials.

Williams P.T, D.G. Jackson, W. Bergman (1984)[18] evaluated the dimensional stability of eleven commercially available impression materials (three polysulfides, one condensation – cured silicone, one polyether and six addition cured silicones) when poured immediately and after storage for 1, 4 and 24 hours. They found that the greatest accuracy occurred when the impression were poured immediately. All the addition cured silicone materials exhibited excellent dimensional stability for all storage times. The condensation – cured silicone materials had good accuracy if poured immediately.

Araujo P.A.D., K.D. Jorgensen (1985)[19] determined the influence of the bulk of elastomeric impression material and size of undercut on the dimensions of stone dies. It was found that both conditions affect the accuracy of stone dies. The data revealed that the increase in thickness of the impression material from 1 to 4mm caused a greater distortion than the height increase of the undercut from 1 to 3mm.

Craig R.G. (1985)[20] investigated to determine the validity of prescribed advantages of automatic mixing system used for an addition silicone impression material ; like simplicity, reduced bubbles in the mix resulting in more precise impression, no spatulation and practically no wasted material. The results showed that a uniform mixing of base and catalyst occurs with the automatic system with one fourth to one fifth bubbles in the mix, compared to mixes obtained by hand spatulation. It also simplifies mixing and nearly eliminates the training of assistants in the mixing of rubber impression materials. The automatic mixing system is economical as it wastes only a third as much material as a typical hand dispensing and mixing system. The properties and accuracy of the system are excellent and typical of addition silicones, including excellent recovery from deformation, low dimensional change on setting, and low flow. So the author concluded that a wash or two phase impression technique may be used with equal clinical accuracy.

Johnson G.H., R.G. Craig (1985)[21] compared the accuracy of four types of elastomeric impression materials (addition silicones, condensation silicone, polysulfide and polyether) by varying the die location, and time of pouring and with a repeat pour of models. There was a little change in dimension among abutment preparation for all materials, for all times of pour and with a repeat pour of models. The addition silicone and condensation silicone products demonstrated the best recovery from undercuts and least change in dimension between an initial and second pour of an impression. The addition silicone and polyether were the least affected with delays of 1, 4 and 24 hours in pouring the impression.

Stackhouse J.A. (1985)[22] reported the relationship between the syringe – tip diameter and the number and distribution of bubbles in extruded strips of impression materials. Two medium viscosity polyvinyl-silicone elastomers were used in the investigation. The results showed that there were significantly fewer bubbles in impression material extrusions from the second half of the syringeful, than from the first half. Also, the smaller tip orifices, 0.6 and 0.67mm in diameter, caused significantly fewer bubbles in the extruded impression materials than did the larger tips.

Arauja P.A.D., K.D. Jorgensen (1986)[23] studied the effect of reheating addition reaction silicone impression on accuracy. The results revealed that reheating the impression to mouth temperature before pouring the dies improved their accuracy. The results also demonstrated that there was more distortion with increasing thickness of impression material.

Drummond. J.L. R.G. Randolph (1986)[24] examined the variability of casts from impression made with four impression materials by using a set of master castings and varying the pour time of the impressions. The four one phase impression materials were condensation silicone, addition silicone and two polyethers. The study also indicated that by altering just one variable i.e. the pour time from one hour to one week, a wide range of results were obtained, some clinically acceptable and other clinically unacceptable.

Johnson G.H., R.G. Craig (1986)[25] evaluated the three impression technique (1. A putty – wash ; 2. A single mix impression and 3. A double mix impression) for addition silicones and compared them with those of the condensation silicone products. They also evaluated the effect of the tray design on the accuracy of the material. They concluded that the most significant differences between types of silicone was that condensation silicone produced significantly shorter dies (2.4% to 0.37%) than addition silicones (0.08%). The same accuracy of impression was achieved for all techniques when addition silicone was used, where as the putty – wash technique produced the most accurate dies for the condensation silicones. The custom trays produced dies that were more accurate in vertical dimensions than the stock trays.

Tjan A.H.L. et al (1986)[26] evaluated the accuracy of reversible hydrocolloid, polysulfide, condensation silicone, polyether and addition silicone and concluded that the elastomeric impression materials exhibited comparable clinical accuracy when properly handled.

Johnson G.H , D.G Drennon (1987)[27] evaluated the reproduction of fine detail of elastomeric impression materials by using combination of techniques. A subject was selected for ¾ and full crown preparation of two posterior maxillary teeth. Identical custom impression trays were constructed and impressions were made. The results showed that double mix techniques produced better detail than single mix. Heavy consistencies, rather than medium, in combination with light – body resulted in better detail.

Schelb E. et al (1987)[28] conducted a study to evaluate the compatibility of five polyvinyl siloxane impression materials with ten modified type IV dental stones. The polyvinyl siloxane impression materials which were used demonstrated greater compatibility when tested with the commercially modified dental stones. They suggested that before using a dental stone with an impression material their compatibility should be determined and this could be made easy if manufacturers of polyvinyl siloxane impression material identify one or more dental stones that are compatible with their products.

Bomberg T.J. et al (1988)[29] determined the effect of some of the adhesion factors of various combinations of trays and adhesive usage which included the use or lack of use of liquid adhesive cement bonding in perforated and non-perforated custom acrylic resin and stock impression trays. The results showed that the most replicative impression and resultant die were found in the single – mix technique with full adhesive application to the custom acrylic resin, stock non perforated and perforated impression trays, and with mechanical retention in perforated custom acrylic resin and stock impression trays. The putty-wash impression technique with full adhesive application yielded poorer but similar results in stock perforated and non-perforated trays, closely followed by the stock perforated tray with no adhesive application. So the authors concluded that the results are enhanced, both in accuracy and consistency, when the adhesive is used in a perforated tray

Johnson G.H, Drennon, L. Powell (1988)[30] evaluated the accuracy and surface quality of stone dies made from impression that had been placed in disinfectants. Results indicated that selection of the type of impression material is more important than selection of the disinfectant. Addition silicone and polysulfide impression were disinfected without a loss in accuracy, whereas polyether impressions were adversely affected.

Reitz C.D., N.P Clark (1988)[31] found that the disadvantage of elastomers is the setting inhibition caused by some brands of latex gloves. They are of opinion that if putty system is used, gloves that do not interfere with setting reaction should be selected.

Chee W.W.L T.E. Donovan (1989)[32] evaluated the fine detail reproduction of ten commercially available very high viscosity polyvinyl siloxane impression material using the American Dental Association specification no 19 stainless steel test die. They found out that the two of the material consistently reproduced the 20 µm line. Three materials were able to reproduce the 20 µm line 50% of the time. The remainder reproduced the 50 and 75 µm line consistently but were unable to reproduce the 20 µm line.

Cullen. D.R James L. Sandrik (1989)[33] conducted the study to evaluate the bond strength between the light body, heavy body and putty rubber base impression materials. The author reported that, the bond strength of about 90psi was adequate. All the products showed good bond strength between light body/heavy body and putty materials. The study showed that, chemical bonding takes place between light body and previously cured putty material and further bond failure that occurred was cohesive failure in the weaker material.

Drennon D.G., G.H. Jonhson, G.L. Powell (1989)[34] examined five disinfectants applied by spray atomization for possible dimensional distortion of elastomeric impression materials and the associated improved type IV gypsum casts. The results showed that the use of a spray disinfectant will not appreciably alter the dimensional accuracy of improved stone casts made within elastomeric impression. The most accurate stone cast system was produced by addition silicone impressions disinfected by a surface spray. It was also shown that four of the disinfectants applied by spray atomization were effective in disinfecting the surface of an elastomeric impression material with selected test organisms.

Chong Y.H et al (1990) [35]examined the relationship between contact angles of the die stone and voids in casts produced from five medium- viscosity impression materials. Contact angles of a die stone material formed against impression specimens made from polyether, addition and condensation silicones were measured by reflex microscope. The results showed that the contact angles of die stone obtained against the hydrophilic addition silicones were intermediate between those of the polyether and other silicone impression materials. The contact angle values correlated significantly with the number of voids found at margins and line angles but not with those on smooth surfaces of the stone casts.

Craig R.G., N.J. Urquiola, C.C. Liu (1990)[36] presented the quantitative data for a comparison of some commonly marketed rubber impression materials with some of the earlier products. The results showed that in general, the qualities of addition silicones and polyethers were superior to polysulfides and condensation silicones. So the author concluded that the selection of a product for a particular application should be based on proper data rather than on the type and class of rubber impression material.

Gordon G.H. Johnson, D.G. Drennon (1990)[37] evaluated the accuracy of reproduction of stone casts made from impressions using different tray and impression material used were an acrylic resin, a thermoplastic and a plastic. Impression were poured at one hour with a type IV dental stone. Results indicated that the custom made trays of acrylic resin and the thermoplastic material performed similarly regarding die accuracy and produced clinically acceptable casts. The stock plastic tray consistently produced casts with greater dimensional change than the two custom trays.

Marshak B., D. Assif, R. Pilo (1990)[38] presented a technique to achieve an accurate seating putty impression tray by use of unprepared teeth and provisional restorations in the arch as landmarks, stop and guiding plane. This technique ensures exact reseating of the putty impression tray and creation of a uniform wash space, which is essential for accurate result.

Saunders W.P et al (1990)[39] investigated the accuracy of casts produced by mixing dental stone with water at different temperatures. Consecutive impressions of an acrylic resin model of the mandibular arch, on which the occlusal surfaces of three teeth had been indented with reference points, were made in poly(vinyl siloxane) impression materials using a one-stage technique. After 1 hour these were cast in stones using water at temperatures of 18 degrees C, 20 degrees C, or 24 degrees C. The distances between the points were measured using a reflex microscope, and the difference between each cast and the model was calculated. Analysis of variance of the mean differences showed that there was no significant interaction between the temperature of the water and the accuracy of casts.

Chai J.V., T.C Yeung (1991)[40] studied the wettability of eight nonaqueous elastomeric impression materials by comparing their contact angles. The results showed that nonhydrophilic poly(vinyl siloxane) materials and the poly(vinyl siloxane) putty were found to be significantly less wettable.

Chong Y.H., G Soh (1991)[41] investigated voids in impressions made by five automixed addition silicone elastomers with and without intraoral delivery tips. The results showed that there was no statistically significant difference in the mean number of voids produced in each automixed silicone dispensed with the use of intraoral delivery tips and the number of voids produced without the use of the tips.

Dounies G.S., G.J. Ziebert, K.S. Dounis (1991)[42] compared the dimensional accuracy of the impression material in the production of working casts in fixed prosthodontics. Prostheses were made on casts constructed from three commonly used impression materials - Polyether, polyvinyl siloxane (medium viscosity and putty-wash). Under the conditions of this study, the following conclusions were drawn. The polyether and addition silicone impression material were significantly more accurate than the reversible hydrocolloid impression material in producing dies for single restorations. However, all of the materials tested produced clinically acceptable single crowns.

Panichuttre R. et al (1991)[43] compared three hydrophilic poly (vinylsiloxane) impression materials, containing an intrinsic surfactant with a hydrophobic poly (vinyl siloxanes) and a polyether impression material. The results showed that the hydrophobic poly (vinyl siloxane) material was dimensionally more accurate than the hydrophilic poly (vinyl siloxanes) in two of three measured dimensions, but the difference was small. The polyether material was the most wettable, and the hydrophilic poly (vinyl siloxanes). However, when a topical surfactant was used, difference in wettability was noted between the hydrophilic and hydrophobic poly(vinyl siloxanes), and their wettability was comparable to the polyether material, indicating that the topical surfactant was more effective than the intrinsic surfactants. Stone dies made from the hydrophobic poly(vinyl siloxane) material were harder than those obtained from the other materials.

Peterson G.F., E. Asmussen (1991)[44] measured the distortion of impression material used in the double-mix techniques. The distortion of combinations of material of high and low viscosity was measured on beam like specimens. Significant differences between materials were observed. The phenomenon may be explained by a swelling of the material of low viscosity. The swelling may be associated with a diffusion of unreacted compounds from the material of high viscosity into the material of low viscosity. Measurements of the swelling of specimens immersed in the catalyst component of unset material showed an increase in length of 2-5%.

Price R.B. et al (1991)[45] determined the dimensional accuracy of dies made using a combination of four impression material and three type IV die stones. Impression of the metal master die were made using three different automix addition reaction silicone impression material and one polyether impression material. Results showed that all of the four stone dies are larger than the metal dies. Although there were significant differences between some of the impression material/ die stone combination, all of the stone dies were measured to be within 9µm of each other.

Saunders W.P et al (1991)[46] examined the accuracy of stone casts produced from impressions made in stock polycarbonate trays, some of which had been strengthened with autopolymerizing polymethyl methacrylate resin. The impression material was a putty- wash polyvinyl siloxane material and five impressions were made for each type of tray. The results of the study showed that the design of tray, or the impression technique employed, has little effect on the accuracy of impressions made with the polyvinyl siloxane materials when used as a putty-wash and a two-stage technique, but accuracy of the impression material within the bulk of the material was affected adversely using a one-stage technique.

Schelb .E et al (1991)[47] evaluated four polyvinyl siloxane impression materials and 14 modified type IV dental stones for their abilities to reproduce surface detail. Each combination of impression material and dental stone was used to duplicate a 20µm wide line. The results showed that the line was reproduced in all impression material specimens, but in only 32% of the stone cast specimens. Some combinations of impression material/dental stone reproduced the line all or most of the time, but 12 combinations did not reproduce the line at all.

Soh.G. Y.H. Chong (1991)[48] investigated voids present in impressions of five auto mixed addition silicone elastomers . Impressions were prepared with putty body impression technique on stainless-steel cylinders with acrylic spacers. The result showed that auto mixed materials generally produced impressions with significantly fewer voids than the hand-mixed material. So the authors concluded that auto mixing was effective in reducing void defects in elastomeric impressions.

Wassell R.W., R.J. Ibbetson (1991)[49] assessed the influence of plastic stock trays on the accuracy of impressions recorded with heavy light-body (HL) and putty light-body (PL) wash impression techniques. Two brands of trays were tested and the same trays were reinforced with acrylic resin. Individual die accuracy and overall distortion of the resultant casts were assessed. PL impressions in both stock trays gave undersized buccolingual dimensions at the preparation finish lines whereas reinforcing the trays reduced this distortion. Resultant overall cast distortion was reduced, but not eliminated, by using reinforced trays with either PL or HL techniques.

Chee W.W.L., T.E. Donovan (1992)[50] reviewed the composition, physical properties, and manipulative variable of polyvinyl siloxane impression materials and the authors recommended that for best results acrylic resin custom trays should be used. The interaction of polyvinyl siloxane materials with latex products was discussed and it was suggested to avoid this interaction; And one of the disadvantages of the impression material is that it has a relatively short working time. So, refrigerating the material will increase working time without affecting accuracy.

Hung S.H et (1992)[51] compared the accuracy of one step versus two step putty-wash addition silicone impression techniques. Five addition silicone impression materials were assessed by measuring six dimensions on stone dies poured from impressions of the master model. They concluded that the accuracy of the addition silicone impression material tested was affected more by the material than by the techniques. The accuracy of the putty-wash, one step techniques was not different from that of putty-wash two step techniques except at one measurement, where the one step impression technique was more accurate than the two step impression techniques.

Lim K.C. Y.H. Chong, G. Soh (1992)[52] examined the voids produced in impressions of an automixed addition – reaction silicone. Two operators took the impressions using material dispensed from either intra oral tips or an impression syringe. The material was also hand mixed for comparison. The results showed that there were no differences in the number of voids in the automixed material dispensed using the intra oral tip or impression syringe. Automixing produced substantially fewer voids than hand mixing. There was a significant difference in the number of voids in the impressions made by the two operators.

Tjan A.H.L. et al (1992)[53] assessed the effect of tray space on the dimensional accuracy and stability of impression made from four brands of monophasic polyvinyl siloxane impression material. They evaluated the accuracy by a quantitative method i.e. by measuring the linear changes of several critical dimensions of the recovered stone dies and also by a qualitative method, i.e. by usual ranking based on the preciseness of the fit of the master castings on the stone dies. They concluded that tray space, as well as repeat pour at later time periods, did not affect the dimensional accuracy and stability of impressions made from monophasic polyvinyl siloxanes. However, the measurement of the interpreparation dimensions appeared to suggest a potential problem for a fixed partial denture when casted in one piece because of a significantly reduced distance between the two abutments. From the findings of this study, it can be concluded that a rigid stock tray can be used with monophasic polyvinyl siloxane impression material.

Robinson P.R., S.M. Dunne, B.J. Millar (1994)[54] determined whether the use of a topical surfactant (Hydrosystem) reduced the number of air bubbles visible on the surface of polyvinyl siloxane impression and stone dies. The results showed that the impressions exhibited a mean of 1.4 ± 2.1 bubbles when Hydrosystem wetting agent was used, which was significantly less than when it was not used (mean 5.5 ± 4.7 bubbles). Dies prepared with Hydrosystem surfactant contained a mean of 0.4±0.8 bubbles, which was significantly less than when Wax – Mate surface agent was used (mean 3.5±5.2). So the authors concluded that in vitro use of Hydrosystem surfactant reduced the number of air bubbles on the surface of silicone impressions and stone dies.

Takahashi H, W.J. Finger (1994)[55] conducted a study to determine the accuracy of the double mix impression relative to the time of placing the tray impression material on preparations covered with medium viscosity polyvinyl siloxane. Addition curing silicone impression materials having different viscosities were used. The observed kinetics showed the possible appearance of elastic characteristics of the syringed material before the tray impression was placed. Accuracy of the impression was not statistically different unless the setting reaction had progressed so that the consistencies of both the syringe and the tray impression were high. These results indicated that the double – mix impression were accurate independent of the curing kinetics of the syringed material alone.

Idris B., F. Houston, N. Claffey (1995)[56] compared the putty-wash one step and two step techniques for making addition silicone impression and stated that the differences in techniques were not considered to be clinically important.

Millar B.J. et al (1995)[57] compared the tear strengths of hydrophilic and hydrophobic polyvinylsiloxane impression materials. The results showed that the inclusion of intrinsic surfactant adversely affects the physical properties of these materials. So the authors concluded that addition cured silicone impression materials which showed lower advancing contact angles, and are therefore more hydrophilic, have lower tear strengths.

Boulton J.L et al (1996)[58] evaluated three elastomeric impression materials which were used in custom and stock trays to determine the accuracy of impressions taken from an experimental stainless steel model representing premolar and molar bridge abutment preparations. The results of the study demonstrated that polysulphide is the least accurate impression material for both vertical and horizontal individual abutment dimensions. However, for inter-abutment horizontal dimensions, no statistical differences were noted between impression material types when using a custom tray. Stock trays produced unreliable results for all the materials tested.

Laufer B.Z. et al (1996)[59] compared the dimensional accuracy of Elite, Examix and Express polyvinyl siloxanes, Permadyne polyether and Permalastic polysulfide elastomeric impression material. These material were used to make impression of a metal model that simulated prepared abutments with gingival sulci of various widths. No great differences could be detected in the distortion of impression of an abutment with sulcular widths greater than 0.2 mm when different impression materials were used. Examix and Permadyne material gave the most consistent and accurate impression with sulci narrower than 0.2mm. None of the impression material used was suitable for sulci 0.05 mm wide because of high prevalence of tears.

Millar B.J. S.M. Dunne, P.B. Robinson (1997)[60] determined whether the use of a surfactant designed for clinical use (Hydrosystem) reduced the number of visible air bubbles on the surface of a range of impression materials. The results showed that Hydrosystem surfactant significantly reduced the number of surface voids when it was used with low-viscosity addition-cured silicone material but not when used with irreversible hydrocolloid, polysulfide, a hydroactive monophase addition-cured silicone, or a putty-wash condensation silicone. So the use of Hydrosystem surfactant may result in a clinically significant improvement in impression quality.

Gus J Livadits (1998)[63] compared the methods and effectiveness of four main impression systems, copper tube/resin coping, syringe/tray, putty-wash and matrix system. Several concepts were questioned and alternative procedures were proposed to eliminate most of the unfavorable while retaining the favorable points.

Millar B.J., S.M. Dunne, P.B. Robinson (1998)[64] compared the number of surface defects in addition-cured silicone impressions recorded with monophase materials in stock trays and two-phase impressions in custom trays. By counting the number of voids visible on the surface of impressions recorded, showed that no significant differences were observed for number of voids between the monophase materials or between the two-phase systems. However, both two-phase materials in custom trays had significantly fewer surface voids than the two-monophase materials used in stock trays. So the authors concluded that monophase addition-cured impression materials in stock trays carries an increased risk of void formation on the surface of the impression when compared with two-phase addition silicone materials in custom trays.

Mahony .A, P. Spencer, K. Williams (2000)[65] determined the effect of retraction cord medicaments (aluminum chloride, ferric sulfate, and ferric subsulfate/ferric sulfate) on the dimensional accuracy and surface detail reproduction of polyvinyl siloxane impressions. The results showed that the medicaments did not significantly affect the dimensional accuracy; mean shrinkage was within ADA guidelines in the treatment groups. All of the medicaments had an adverse effect on surface detail reproduction. These effects were statistically significant compared to the untreated control.

Nissan J. et al (2000)[66] studied the accuracy of 3 putty wash impression techniques using the same impression material (polyvinyl siloxane) in a laboratory model. The 3 putty wash techniques used were 1 step (putty wash impression material used simultaneously), 2step with 2mm relief and 2 step techniques with a polyethylene spacer. For each techniques, 15 impressions were made of a stainless steel master model that contained 3 complete crown abutment preparations, which were used as positive controls. Accuracy was assessed by measuring 6 dimensions on stone dies poured form impression of the master model and they concluded that the polyvinyl siloxane 2 step, 2mm relief putty wash impression techniques was the most accurate for fabricating stone dies.

Ragain J.C et al (2000)[67] conducted a study to compare interfacial contact angles, and die hardness for some combinations of elastomeric impression and die materials. Representative polyvinyl siloxanes, polysulfide, polyether, and reversible hydrocolloid impression material and type IV , type V, and resin reinforced – type IV die materials were evaluated using a factorial design. The results showed that for both contact angle and die hardness, a statistically significant interaction between the impression and die materials were found.

Dhiman R.K., S.K. Agarwal., R.C. Dhir (2001)[68] compared the accuracy of reproduction of addition silicone impression material (Reprosil) with putty wash one step and two step techniques. The result showed that two step techniques produced more accurate casts with less standard deviation. It was also observed that in general, the material produced slightly larger casts as compared to the master die.

Milward P.J, M.G. Waters (2001)[69] evaluated the effect of disinfection procedures and the use of a surface wetting agent on the wettability of 4 addition-polymerized silicone impression materials. Two disinfection solutions (Actichlor and Perform) and one wetting agent (Vacufilm) were used. The results showed that disinfection with Actichlor is recommended in preference to Perform to maintain the wettability of impression materials. Treatment with Vacufilm after disinfection is recommended to improve the wettability of materials and thus reduce the likelihood of voids within casts.

Lepe X et al (2002)[71] compared wettability, and mass change of various recently introduced automixed low-viscosity addition silicone and polyether materials before and after immersion for disinfection. The results showed that the two polyether materials tested exhibiting significantly lower advancing contact angle and reducing contact compared with the five addition silicones higher. Polyether materials lost significantly more (0.6% to 0.8%) and Aquasil LV (addition silicone) gained significantly more (0.6%) mass in air.

Thongthammachat S. et al (2002)[72] evaluated the influence on dimensional accuracy of dental casts made with different with types of trays and impression materials and poured at different and multiple times. The results showed that accurate casts can be made with either stock trays or custom trays. An impression made from polyether should be poured only once and within 24 hours after impression making, because of the distortion of the material over time. Silicone impression material has better dimensional stability than polyether.

Johnson G.H. L. Lepe, T.C. Aw (2003)[75] determined whether type of material, viscosity selection, and presence of moisture affect detail reproduction of elastomeric impressions. The results showed that single viscosity systems reproduced the standard saw-tooth pattern better than the dual viscosity systems, as did polyether impression materials compared to addition silicones. Moisture led to a lower mean roughness or less detail compared to dry conditions.

Ceyhan J.A , Johnson G.H (2003)[76] compared the accuracy of working dies made from impressions with metal and plastic trays, for 2 different viscosities of impression tray material. The result showed that the monophase material, when compared with the rigid impression material, was most accurate for the occlusogingival and mesiodistal dimensions, although not as accurate in the buccolingual. When a monophase impression material was used, plastic trays yielded gypsum dies which were significantly smaller than the ones generated from the metal trays.

Omar R , Abdullah M.A et al (2003)[77] compared the accuracy of stone models obtained from two-stage, pre-spaced putty/wash impressions under conditions in which known volumes of wash material were introduced during the second stage of the impression: It was concluded that putty recoil, resulting from compression by excess wash material, plays a significant role in the undersizing of working dies.

Abdelaziz K.M, Hassan A.M (2004)[79] evaluated the reproducibility of rubber impressions after sterilization by different methods. Dimensional accuracy and wettability of two rubber impression materials (vinyl polysiloxane and polyether) were evaluated after sterilization by each of three well-known methods (immersion in 2% glutaraldehyde for 10 h, autoclaving and microwave radiation). Non-sterilized impressions served as control. The effect of the tray material on impression accuracy and the effect of topical surfactant on the wettability were also evaluated. They concluded that a) sterilization of rubber impressions made on acrylic trays was usually associated with a degree of dimensional change; b) microwave energy seems to be a suitable technique for sterilizing rubber impressions; c) topical surfactant application helped restore wettability of sterilized impressions.

Lampe I , Morton S (2004)[80] evaluated the effect of mixing technique on shrinkage rate of one polyether and two polyvinyl siloxane impression materials. Shrinkage rates of the same materials mixed using different techniques were compared 30 minutes, 24 hours, and 72 hours after mixing. The results showed that there was no significant difference in dimensional changes when hand- and cartridge-mix techniques were compared at the same measuring time for the tested polyvinyl siloxane materials. The cartridge-mix technique for the polyether material showed significantly higher shrinkage at 24 and 72 hours, while the mean shrinkage rate of all materials showed a significant time-dependent increase.

Cho G.C , Chee W.W (2004)[81] evaluated the rigidity and ability to resist deformation of plastic stock trays and metal stock tray when used in conjunction with a high-viscosity vinyl polysiloxane impression material and concluded that when disposable plastic stock trays were used, there was distortion of the tray both across the arch and in cross section.

Shah S , Sundaram G et al (2004)[82] compared the dimensional accuracy of an impression technique using a polyether material (Impregum) and a vinyl poly siloxane material (President) using a laser scanner with three-dimensional superimpositional software and concluded that both impression materials provided an accurate replica of the prepared teeth supporting the view that these materials are highly accurate.

Chen S.Y, Liang W.M (2004)[83] evaluated the effects of various impression materials, different storage times and the proportion of inorganic filler on the accuracy and stability of elastometric impression materials. The results showed that there was a significant interaction effect between materials and storage times on the accuracy of the impressions. Addition type silicone materials had the greatest accuracy and stability and the alginate impression material had the least accuracy. When the experimental material had a low proportion of filler, there was a significantly greater dimensional discrepancy compared to the same material with a higher proportion of filler.

Wadhwani C.P , Johnson GH et al (2005)[84] assessed the accuracy of fast-setting elastomeric impression materials when disinfected with acid glutaraldehyde. Measurements of the master model and working casts included anteroposterior (AP) and cross-arch (CA) dimensions. A stainless steel circular crown preparation incorporated within the master model was measured in buccolingual (BL), mesiodistal (MD), and occlusogingival (OG) dimensions and compared to measurements from recovered gypsum dies. The result doesnot show any significant difference.

Forrester-Baker. L et al (2005)[85] compared the dimensional accuracy between three different addition cured silicone impression materials. Ten impressions were made with each of three addition-cured silicone impression materials. Comparison of the measurements indicated that the mean dimension measured from the shoulder region for each group of impression materials was significantly different from those taken from the original metal abutment. However, when these impressions were cast in a gypsum based die material, none of the measured dimensions taken from the casts were significantly different from those taken from the original metal abutment. Thus, any change in measured dimensions occurring during impression making, was compensated for in some way by the casting process.

Samet N , Shohat M (2005)[86] evaluated the quality of impressions sent to commercial laboratories for the fabrication of fixed partial dentures by describing the frequency of clinically detectable errors. The result showed that impressions made with polyethers had the most detectable errors followed by condensation-type silicones. The high frequency of detectable errors found in impressions sent for FPD fabrication is of concern.

MATERIALS AND METHODS

MATERIALS

- Metal master model
- Modelling wax (manufacturer INDU)
- Auto polymerizing resin (DPI-RR cold cure)
    - For custom tray construction
- Tray adhesive (3M ESPE)
- Impression materials

Addition polyvinyl siloxane impression materials from IVOCLAR VIVADENT (fig.1) were used and the viscosities used were as follows:

- VIRTUAL low viscosity (cartridge form)
- VIRTUAL medium viscosity (cartridge form)
- VIRTUAL high viscosity (cartridge form)
- VIRTUAL bite registration (cartridge form)
- VIRTUAL putty consistency

- Type IV die stone (KALABHAI)

Armamentarium

- Polyethylene sheet
- Rubber bowl
- Dispensing cups
- Measuring jar
- Weighing machine
- Plaster spatula
- Mechanical vibrator (VIBRO C-70)
- Camel hair brush
- Straight fissure bur (TC bur)
- Weswox High resolution Travelling microscope (model HEL 7)
- Vernier calipers
- Ivansons calipers
- Williams probe
- Reading lens.

METHODOLOGY EMPLOYED IN THE STUDY

(I) PREPARATION OF MASTER MODEL

A metal master model (fig.2), comprising two fixed partial denture (FPD) abutment preparations (α and β) were fabricated by "Turning procedure" for making the measurements in this study. The abutments were prepared with a taper of 6 degrees. The metallic model consists of a horizontal platform with a height of 10mm in which a groove of 2mm depth on one side and two depressions on the other side were made for the orientation of the tray during impression making. The metallic dies simulating the abutment preparations (α and β) were mounted on the base with the help of screws attached from underside of the platform. They were of 10 mm height and 6mm and 10mm in width respectively. Three reference markers in the form of depressions were made on the surface of abutment α, one in the center of occlusal surface and other two on the lateral surface which are approximately 2mm and 6mm from the occlusal surface. These two points were used to measure variation in the occluso-gingival direction if any.

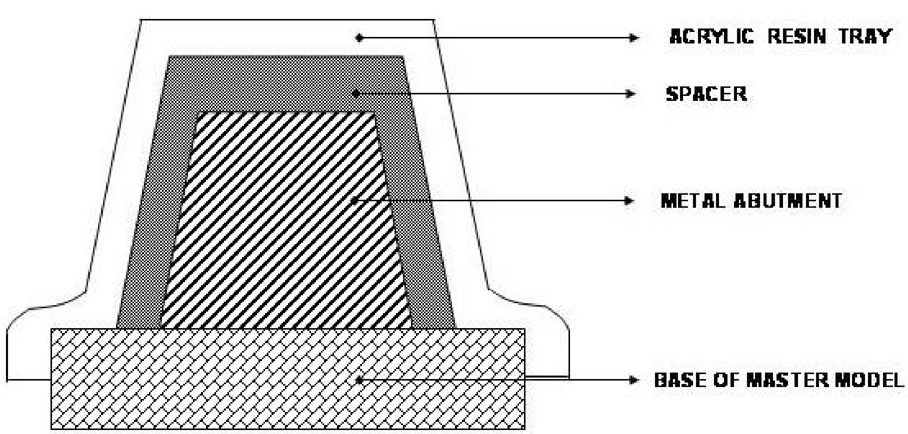
Similarly five reference markers were made on the occlusal surface of abutment β, one in the center and other 1mm from the peripheries of mesial, distal, labial and lingual aspects of occlusal surface. These points were used to measure variation in mesio-distal and labio-lingual direction if any. Metal coping of 2mm thickness throughout were fabricated to fit precisely on both abutment preparations.

TABLE 1: Description of reference points

Reference points	**Description**
A	Center of abutment α
B	Center of abutment β
C	Mesial reference point in abutment β
D	Distal reference point in abutment β
E	Labial reference point in abutment β
F	Lingual reference point in abutment β
G	Occlusal reference point in abutment α
H	Gingival reference point in abutment α

(II) FABRICATION OF IMPRESSION TRAYS (fig.3)

Forty, identical rigid custom impression tray with uniform thickness of 2mm were fabricated using auto polymerizing acrylic resin, which could be placed on to the platform of the metallic model accurately with the help of grooves and depressions engraved on the horizontal platform for the purpose of orientation, thus preventing the rotation of the tray. Initially modelling wax of 3mm thickness was adapted to the model. Tissue stops were created mesial and distal to the abutment. Polyvinylsiloxane impression was made from the master model along with the wax spacer and casts were poured with type III dental stone and obtained. This stone cast was used to fabricate 40 identical rigid custom trays with uniform thickness of 2mm using auto polymerizing resin. This ensured that the internal dimensions of all the trays remained the same, thus ensuring intimate adaptation and rigidity for making final impression.



(III) SEGREGATION OF THE IMPRESSION TECHNIQUES

The final impressions to be made with silicone elastomers were segregated into 4 groups viz

Group I: Single stage technique in which putty and wash impression materials were used simultaneously and the casts obtained from them were segregated as group I casts.[70] (fig.4 & 5)

Group II: Double stage technique in which a polyethylene spacer was used with putty impression first and followed by the wash impression after removal of the polyethylene spacer. The casts obtained from them were segregated as group II casts.[70] (fig.6 & 7)

Group III: Double stage technique in which 2 mm coping covering the abutments was used with the putty first to make a preliminary impression, so that a uniform 2 mm space is created and then followed by wash impression. The casts obtained from them were segregated as group III casts. (fig.8 & 9)

Group IV: Matrix impression technique in which an occlusal registration material was used first to form a matrix which is relined using high viscosity material and picked up using an impression tray filled with medium viscosity impression material. The cast obtained from them were group IV.[62] (fig.10& 11)

The tray adhesive was coated on the internal surface of the tray and air dried for 5 minutes before making the impressions. The use of tray adhesive enhance the results both in accuracy and consistency.[29, 15]

DESCRIPTION OF IMPRESSION TECHNIQUES

GROUP I IMPRESSIONS (fig.4)

Equal amount of putty base and catalyst were hand mixed without gloves because some brands of latex gloves cause the setting inhibition of elastomers[50] and loaded on to the perforated custom tray. Simultaneously, the light body (Virtual) impression material was injected over the abutments with an automatic mixing syringe with a tip attached to it. A mechanical mixing system was used because of its simplicity, reduced bubbles in the mix resulting in more precise impressions, no spatulation and being economical.[41] Once the wash impression material was injected, the tray loaded with putty material was seated on to the abutments and was held in place for 8 minutes for the material to set.

GROUP II IMPRESSIONS (fig.6)

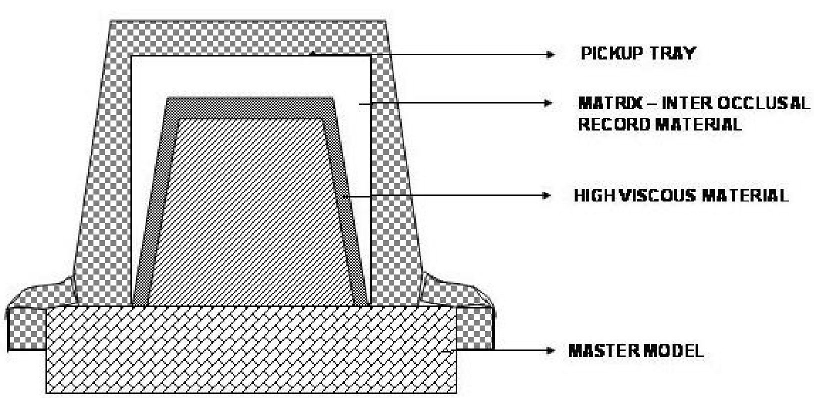
Initially impression was made in the putty material with the polyethylene spacer on the master model. The impression was allowed to set for 5 minutes. Once the impression was set, the spacer was removed and the final (light body) impression material was injected over the abutments and the tray was reseated over the master model accurately. The tray was held in place allowing the material to set for 8 minutes.

GROUP III IMPRESSIONS (fig.8)

Initially impression was made in the putty material with 2mm copings on the abutment preparations. After the putty material was set, the copings were removed and the final (light body) impression material was injected over the abutments and the tray was reseated over the master model accurately and the material was allowed to set for 8 mins. The light body material occupies the space of 2mm all around, created by removing the copings.

GROUP IV IMPRESSIONS (fig.10)

Initially impression was made with the occlusal registration material on the abutment preparations using a carrier (pre-made with vaccum-forming equipment). Occlusal registration material was used because of its semi rigidity and superior stability. The carrier should provide at least 2-3mm of space between its walls and the abutment. It was allowed to set for 5 mins. Matrix was then removed from the carrier and scalpel was used to trim the matrix till the finish line margin. Then the final (heavy body) impression material was injected over the abutments and the matrix was reseated over the master model. Immediately medium viscosity impression material was loaded in an impression tray and seated over the matrix and allowed to set for 8 minutes.[62]



(IV) PREPARATION OF THE MASTER CAST

After the impressions were completed, they were stored at room temperature for 30 minutes before being poured. All the impressions were sprayed with surfactant and blow dried as it reduces the surface tension of the elastomers and results in void free casts.[60]

Then 12 ml of distilled water was dispensed in the jar of vacuum mixer and 50 g of improved dental stone (type IV) was sifted gradually in to the water and allowed to soak for 30 seconds. Type IV die stone was used because it has a minimal linear setting expansion of 0.1 percent. Later the stone was mechanically mixed under vacuum for 30 seconds. The small increments of the stone mix were placed in the impression which was placed on the vibrator by using the camel hair brush from one end of the impression. The stone mix was directed in to the prepared abutment impression with the help of a probe and extreme caution was observed to avoid entrapment of the air bubbles. After pouring the casts, the stone was allowed to set for 1 hour before separating the casts from the impression.

The obtained casts were checked for voids and the defective casts were discarded. Each cast was trimmed and labeled according to the group. 10 such impressions were made for each group and the casts were poured to obtain the master casts.

TABLE 2: Description of locations measured

Location	Description
AB	Points measuring Inter abutment distance
CD	Points measuring Mesio-distal dimension
EF	Points measuring Labio-lingual dimension
GH	Points measuring Occluso-gingival dimension

(V) Measurement of dimensional accuracy

The dimensional accuracy of the impressions was determined directly by measuring the die by non-contact method using Weswox high resolution travelling microscope (fig.12). It had a least count i.e. minimum possible distance measured by the device was 0.001 cm so that it has the accuracy of 0.001 centimeter. The magnification produced by the microscope was 25 times of its original image.

The measurement was done by focusing the entire distance i.e. from one point to the opposing point to be measured. Here In-focus technique was used to avoid parallax error. To determine the accuracy at each site, the surface to be measured was focused till the point was clearly appreciable. The marker on the magnifying lens was aligned at the center of one point and the tightening screws were tightened so that it does not move while recording the main scale reading(MSR) no.1 and Vernier scale count (VSC) no.1. The vertical arm of the microscope was then moved laterally till the marker on the magnifying lens is at the center of the opposing point and screw tightened and the main scale reading no.2 and vernier scale count no.2 was taken.

Vernier scale reading (VSR) no.1 was obtained by multiplying VSC no.1 and least count (LC), that is, the least count the microscope can measure, which is constant at 0.001cm. VSR=VSC x LC. From this correct reading (CR) for reading no.1 can be calculated by using the formulae CR = MSR + VSR. Likewise correct reading (CR) for reading no.2 was calculated. Finally the distance between the two points was obtained by subtracting CR no.1 and CR no.2. For example to measure the distance between point A and point B, that is, the inter abutment distance, the CR of point A and B were determined respectively first and their difference gives the correct distance between them.

In the same way mesio-distal, labio-lingual and occluso-gingival dimensions were calculated for each die and the standard metal master model. The readings obtained were tabulated according to groups and this procedure was followed for all the 10 dies in each group.

RESULTS

The aim of the study was to compare the accuracy of stone casts obtained from single stage putty-wash, double stage putty-wash with polyethylene spacer, double stage putty-wash with 2mm spacer and matrix impression technique.

The impressions made by single stage putty-wash technique were considered as group I impressions, double stage using polyethylene spacer as group II impressions, using 2mm coping as group III impressions and matrix impression technique as group IV impressions.

10 impressions were made in each group and the casts obtained from them were considered as group I, II, III, IV casts respectively.

The dimensional changes of the casts obtained from the various impression techniques were measured and analysed using Weswox High resolution Travelling microscope (model HEL 7). Each measurement was analyzed 3 times by the same operator; the mean was calculated, tabulated and statistically analyzed. Descriptive statistics like mean, standard deviation were calculated for each group and differences. Their level of significance is calculated by one sample t-test and One-way analysis of variance (ANOVA) followed by multiple range test by Tukey-HSD procedure was used for multiple group comparison.

A p-value of less than 0.05 was considered for significance.

TABLE-3: shows the measurement of inter abutment distance (AB) between master model and different groups. (In millimeters)

SPECIMEN NO	MASTER MODEL	GROUP I	GROUP II	GROUP III	GROUP IV
	18.70				
1		18.85	18.80	18.70	18.80
2		18.91	18.80	18.73	18.81
3		18.86	18.77	18.71	18.77
4		18.87	18.77	18.71	18.77
5		18.87	18.78	18.76	18.79
6		18.91	18.80	18.73	18.75
7		18.90	18.82	18.72	18.74
8		18.92	18.79	18.72	18.74
9		18.89	18.80	18.74	18.76
10		18.93	18.79	18.74	18.77

TABLE-4: shows the measurement of mesio-distal distance (CD) between master model and different groups. (In millimeters)

SPECIMEN NO	MASTER MODEL	GROUP I	GROUP II	GROUP III	GROUP IV
	9.02				
1		9.09	9.04	9.02	9.05
2		9.08	9.03	9.02	9.05
3		9.06	9.02	9.02	9.06
4		9.07	9.04	9.03	9.06
5		9.08	9.05	9.04	9.05
6		9.08	9.04	9.04	9.03
7		9.07	9.06	9.03	9.04
8		9.05	9.05	9.04	9.07
9		9.06	9.05	9.02	9.04
10		9.08	9.04	9.03	9.07

TABLE-5: shows the measurement of labio-lingual distance (EF) between master model and different groups. (In millimeters)

SPECIMEN NO	MASTER MODEL	GROUP I	GROUP II	GROUP III	GROUP IV
	8.49				
1		8.50	8.51	8.50	8.53
2		8.55	8.54	8.52	8.53
3		8.54	8.53	8.49	8.53
4		8.56	8.54	8.50	8.52
5		8.53	8.54	8.50	8.50
6		8.54	8.53	8.51	8.53
7		8.55	8.57	8.48	8.52
8		8.57	8.54	8.51	8.50
9		8.54	8.55	8.49	8.51
10		8.54	8.53	8.51	8.54

TABLE-6: shows the measurement of Occluso-gingival distance (GH) between master model and different groups. (In millimeters)

SPECIMEN NO	MASTER MODEL	GROUP I	GROUP II	GROUP III	GROUP IV
	4.23				
1		4.25	4.24	4.23	4.27
2		4.27	4.23	4.24	4.25
3		4.28	4.23	4.25	4.27
4		4.28	4.27	4.24	4.27
5		4.29	4.25	4.24	4.25
6		4.29	4.25	4.25	4.27
7		4.30	4.22	4.26	4.29
8		4.29	4.25	4.24	4.29
9		4.29	4.24	4.26	4.30
10		4.25	4.24	4.23	4.26

TABLE 7: Shows mean, standard deviation, percentage deviation and test of significance of mean values with the actual values in different study group for inter abutment distance (AB)

Group	Mean	Standard Deviation	Actual Value	p-value	Percentage deviation
			18.70		
I	18.892	0.019		0.01(sig)	1.03%
II	18.792	0.013		0.07(n.sig)	0.49%
III	18.726	0.016		0.53(n.sig)	0.14%
IV	18.771	0.008		0.20(n.sig)	0.38%

For inter abutment distance, the mean value in group I is significantly higher than the actual value. However the mean value in group II, III and IV are not significantly different from the actual value and the amount of percentage deviation of group III was less when compared with other groups. This suggests that group III casts are more accurate, followed by group IV, II and I. But group comparison by using one way ANOVA followed by multiple range test by Tukey-HSD procedure shows no significant difference among all four groups.

TABLE 8: Shows mean, standard deviation and test of significance of mean values with the actual values in different study group for mesio-distal dimension (CD)

Group	Mean	Standard Deviation	Actual Value	p-value	Percentage deviation
			9.02		
I	9.072	0.004		0.007(sig)	0.58%
II	9.042	0.008		0.49(n.sig)	0.24%
III	9.028	0.006		0.52(n.sig)	0.10%
IV	9.051	0.006		0.10(n.sig)	0.34%

For mesio-distal distance, the mean value in group I is significantly higher than the actual value. However the mean value in group II, group III and group IV are not significantly different from the actual value and the amount of percentage deviation for group III was less when compared with other groups. This suggests that group III casts are more accurate, followed by group II, IV and I. But group comparison by using one way ANOVA followed by multiple range test by Tukey-HSD procedure shows no significant difference among all four groups.

TABLE 9: Shows mean, standard deviation and test of significance of mean values with the actual values in different study group for labio-lingual dimension (EF)

Group	Mean	Standard Deviation	Actual Value	p-value	Percentage deviation
			8.49		
I	8.542	0.006		0.02(sig)	0.61%
II	8.538	0.007		0.04(sig)	0.57%
III	8.501	0.009		0.78(n.sig)	0.12%
IV	8.521	0.005		0.05(n.sig)	0.35%

For labio-lingual distance, the mean value in group I and II are significantly higher than the actual value. However the mean value in group III and IV are not significantly different from the actual value and the amount of percentage deviation for group III was less when compared with other groups. This suggests that group III casts are more accurate, followed by group IV, II and I. But group comparison by using one way ANOVA followed by multiple range test by Tukey-HSD procedure shows no significant difference among all four groups.

TABLE 10: Shows mean, standard deviation and test of significance of mean values with the actual values in different study group for occluso-gingival dimension (GH)

Group	Mean	Standard Deviation	Actual Value	p-value	Percentage deviation
			4.23		
I	4.279	0.020		0.33(n.sig)	1.16%
II	4.242	0.014		0.85(n.sig)	0.28%
III	4.244	0.013		0.76(n.sig)	0.33%
IV	4.272	0.009		0.21(n.sig)	0.99%

For occluso-gingival distance, the mean values of all the four groups are not significantly different from the actual value. The amount of percentage deviation of group II was less when compared with other groups.. This suggests that group II casts are more accurate, followed by group III, I and IV. Group comparison by using one way ANOVA followed by multiple range test by Tukey-HSD procedure also shows no significant difference among all four groups.

DISCUSSION

Successful fabrication of a fixed prosthesis ardently requires accurate replicas of dental and dentoalveolar structures that are treated. Over the past four decades, tremendous progress has been made in the principles, concepts and procedures for making impressions for fixed prosthodontics. Among the multitude of impression materials that were used in fixed partial prosthodontics, the elastomers have emerged as the most superior medium of registration. Among the four commonly used elastomers, namely polysulfide, condensation silicones, addition silicones and polyether elastomers, poly vinyl siloxane (PVS) is one such impression material which ardently satisfies all the protocols of a successful impression making procedure. [9,12,13,15,18]

Polyvinyl siloxane (addition silicone) impression materials were selected for this study because of their excellent physical properties, handling characteristics and dimensional stability[12,13,26,20,42]. The addition silicone is highly recommended by clinicians as it overcomes the problems associated with polymerization shrinkage of the condensation silicone impression material.

The accuracy of the impression material that is being used also depends on the type of tray used[37], tray adhesive[29] and the impression technique.

Putty-wash impression technique is clinically the most popular impression technique because of its simplicity[50], accuracy, easy handling properties and considerable reduction in clinical and laboratory maneuvers when compared with other contemporary impression materials and techniques. Putty materials are heavily filled, thus restricting the polymerization shrinkage to its minimum. In addition to this, material with relatively lesser filler content is necessary for recording fine details of the structures.

As far as polyvinyl siloxane impression materials are concerned, it has been established that the bond strength between putty and wash material is sufficient enough to overcome stress that tend to separate the materials at their interface.[17]

Matrix impression is a new system that incorporates the basic three variations in the viscous behavior of the elastomers in a synergistic fashion to obtain an accurate impression. This new method can significantly improve the gingival displacement and sulcular cleansing during impression making as it has got an effective control over the four forces (relapsing, retraction, displacement and collapsing) acting on the gingiva in a favourable mode during the registration of subgingival margins in the critical phase of impression making.[62]

Hence the evolution of newer innovative techniques in impression making in fixed partial prosthodontics greatly demands the proper selection of an impression technique to achieve clinical success. The basic putty-wash technique with its modifications is contemporary choice to clinicians for impression making. The innovative matrix impression technique advocated by Gus J. Livaditis[62] can provide adequate gingival retraction along with an accurate impression as reported by the author. Hence this study was aimed to compare the accuracy of stone cast obtained from the most widely used putty-wash impression technique, its clinical variants and modifications and the new matrix impression technique.

Here four impression techniques were selected namely single stage putty-wash, double stage putty-wash with polyethylene spacer, double stage putty-wash with 2mm spacer and matrix impression technique for this study and the casts obtained from these impression techniques were compared with a custom made metallic die acting as a control.

In this in vitro study, the impressions made by single step putty-wash technique were considered as group I impression and the casts obtained by them were considered as group I casts. The impressions made by two step putty-wash technique using polyethylene spacer were considered as group II impression and the casts obtained by them were considered as group II casts. The impressions made by two step putty-wash technique using 2mm spacer were considered as group III impression and the casts obtained by them were considered as group III casts. The impressions made by matrix impression technique were considered as group IV impression and the casts obtained by them were considered as group IV casts.

The measurement of die poured from impressions is clinically a more reliable method of assessing the accuracy of the impression than by direct measurement of the impression. This is because the accuracy of the die will to a larger extent determine the final fit of the restoration. In addition, it would be difficult to view microscopically the critical part of a preparation within an impression.[66]

The master model, group I, II, III, IV casts were analyzed using Weswox High resolution Travelling microscope (model HEL 7) in Research Department of Physics, Saveetha Engineering College, Chennai and the results were tabulated and compared using one sample t-test and one way analysis of variance (ANOVA) followed by multiple range test by Tukey-HSD procedure .

For the analysis of impression, linear measurements can be made with suitable reference points by contact or non contact methods. Contact methods include the use of vernier calipers, micrometer, dual gauge or linear variable differential transformer. Non-contact methods generally involve a travelling microscope, toolmakers microscope or reflex microscope, which is capable of making measurement in three dimensions. In this study a non contact measurements were preferred as they avoid the risk of die abrasion by the measuring instrument and Weswox High resolution travelling microscope was used.

Group I casts which were obtained from single step putty-wash impression technique showed the greatest variation from the master model. This discrepancy can be attributed to the lack of accurate standardization as the base and catalyst are mixed by volume and not by weight and also there is no absolute control of bulk, there are more chances of putty material displacing the wash material, in some situations parts of the prepared tooth, including margins are duplicated with putty instead of syringe material. Finally by mixing the putty material at the same time as the syringe material, the setting distortion of the putty by polymerization shrinkage is included in the overall distortion of the impression. Hence the resultant shrinkage is the total polymerization shrinkage of putty and wash material together as was in confirmation with the studies made by Idris.B et al[56] and Nissan.J et al[66] who showed an increase in the size of die when one step putty wash technique was used.

Group II casts which were obtained by double stage impression technique using polyethylene spacer showed significantly more accuracy than group I because polymerization shrinkage of putty is not incorporated as the wash impression is made only after putty sets. The limitation with this technique is when a polyethylene spacer is used, there is no absolute control on bulk of wash material resulting in a uneven and a bizarre mode of polymerization shrinkage of the wash material resulting in either oversized or undersized die as confirmed with the studies made by Chee.W et al,[32] Dhiman.R.K et al[68], Johnson.G.H et al[27] and Nisan.J[66] et al as they reported that dimensional stability was better with 2-step technique when compared to one step technique.

Group III casts which were obtained by double stage impression technique using 2mm spacer showed the least variation in dimension when compared with the master model and other group casts and was considered the most accurate. This is because of the 2mm uniform thickness of the wash material supported by putty matrix resulting in a minimal and even mode of polymerization shrinkage towards the tray resulting in a slight increase in the dimension of the die when compared to the master model. Nissan.J et al [66] have reported similar findings with this technique in their studies which is coincident with the findings observed in this study.

Eames.W.B et al [8] reported that 2mm thickness of rubber base material provided accurate impression than 4 and 6 mm thickness, because of lesser polymerization shrinkage. Fairhurst.C.W et al[1] and Nissan.J[66] et al also reported that the most accurate impressions are produced by providing a wash space of 2mm. Increasing the thickness of the impression material, produces more distortion because of greater polymerization shrinkage.[19] Less than 2mm of wash space doesnot provide adequate bulk of wash material.

Group IV casts which were obtained from matrix impression technique showed some variation with the master model and the cast obtained by group III impressions. This can be attributed to the viscosity of the material that is used to record the fine detail being too high and the increase in dimension of the cast may be because of the polymerization shrinkage of the high viscous material towards the occlusal registration material which is used as a matrix. Semi rigidity of the occlusal registration material also contributes to the dimensional change.[80]

The statistical results revealing the degree of accuracy of the dies obtained from various impression techniques against the master model is ranked in the following sequence – group III, group II and IV, and group I in succession by using one sample t-test. Then the final comparison regarding the efficacy of the four impression techniques were analyzed using one-way analysis of variance (ANOVA) followed by multiple range test by Tukey-HSD procedure. The results concluded that despite subtle variations in tissue reproduction and dimensional behavior in the casts occur with four impression techniques when compared against the standard metallic master model, they were of minor statistical significance and very negligible clinical significance thus warranting the successful application of putty-wash technique and the new matrix impression technique in clinical situations.

The limitation of this study is that the assessment of dimensional accuracy of different impression techniques was done by using simple geometric specimens which does not simulate all clinical conditions. The variables such as, the condition of oral cavity, temperature and moisture that may affect one technique more than the other was not considered in this study.

This study provides further scope for research by incorporating a higher degree of precision instruments and also the forthcoming studies could involve a greater number of samples from the population and could be carried out as an invivo trial.

SUMMARY AND CONCLUSION

The therapeutic success of fixed Prosthodontics is often determined by the accuracy of the impression that is being made. Any flaw in the impression making greatly magnifies the risk of failure of the finished restoration.

Among the various impression materials, elastomers are the ideal medium of choice in contemporary trends of FPD. The PVS elastomers enjoy the maximum superiority over the other elastomers as supported by numerous clinical studies.[9,12,13,15,18] To further replenish the validity of PVS elastomers regarding its accuracy in reproduction of tissue surface this study was aimed at comparison of accuracy of the stone cast obtained from single stage putty-wash, double stage putty-wash with polyethylene spacer, double stage putty-wash with 2mm spacer and matrix impression technique.

In group I category of impressions, putty and wash material were used simultaneously. In group II category of impressions, initially putty impression was made using a polyethylene spacer followed by addition of wash material to make final impression. In group III category of impressions, initially putty impression was made over the abutment preparation covered with a coping of 2 mm thickness followed by final impression with wash material after removal of the 2 mm coping. In group IV category of impressions, initially matrix is made with inter occlusal record material, then it is relined with high viscous material and the entire matrix is picked up using medium viscous material.

Ten impressions were made in each group, poured with type IV dental stone and the casts were obtained, followed by the analysis of the dimensional accuracy of the cast with the master model and the results were evaluated.

When the working casts of the four groups were compared with the master model, it showed that all the groups exhibited minimum deviation which is of very minor statistical significance as determined by one sample t- test. The accuracy of the techniques from a statistical point is that the cast obtained from group III impressions exhibited maximum reproduction of the master model closely followed by groups II and IV and then by group I.

Even though percentage deviation of statistical significance was observed by one sample t – test, the relative accuracy of each technique and clinical significance analyzed by means of one way ANOVA followed by multiple range test by Tukey-HSD procedure revealed that the subtle changes observed in the accuracy of various impression techniques used could be of a highly negligible clinical significance.

Within the limitation of this study, the following conclusion can be drawn,

1. The accuracy of stone casts obtained from double stage putty wash with 2 mm spacer was the maximum, followed by matrix impression technique and double stage putty wash with polyethylene spacer, then by single stage putty wash impression technique.

2. The discrepancy between various impression techniques were of minor statistical deviation and hence considered clinically negligible, thus endorsing the close ramification of these four techniques with respect to reproduction of tissue detail ensuring its successful application in routine clinical procedures.

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