Original Article

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Dentistry Section

Comparative Evaluation of the Dimensional Accuracy of Closed Tray and Open Tray Impression Technique for Dental Implants using Two Different Impression Materials

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ABSTRACT

Introduction: In the era of fixed prosthodontics where implant restorations are being routinely used, it is imperative for the dentist to correctly record the position and orientation of the implant. This necessitates the application of correct impression procedure, impression material and accurate die materials.

Aim: This study aims at evaluating and comparing the effect of closed tray and open tray impression technique with polyvinyl siloxane and polyether as impression materials on the dimensional accuracy of implant definitive casts.

Materials and Methods: This in vitro study is about implant definitive casts made using the open tray and closed tray impression technique using two different impression materials i.e., polyvinyl siloxane and polyether. The Co-ordinate measuring machine was used to evaluate the dimensional accuracy of the casts, then tested at the Tata Autocomponents-Interiors and Plastic Division (IPD), Pune. A total of 60 implant definitive casts were made. A total of 30 casts were made using each impression technique. These casts were further subgrouped wherein, 15 casts were made using polyvinyl siloxane as the impression material and 15 casts were made using polyether. The unpaired t-test was used for comparison.

Results: Both the open tray and closed tray impression technique are comparable to each other and there is no statistically significant difference between the two. Also, the impression materials are equally good for impression making of implants ($p>0.05$).

Conclusion: Either of the impression techniques and material used in the study can be used to make implant definitive casts.

Keywords: Direct impression technique, Indirect impression technique, Pick-up impression technique, Polyvinyl siloxane, polyether

INTRODUCTION

The use of dental implants to rehabilitate partially and completely edentulous patients is a routine procedure in today's time. There have been numerous clinical studies to support the long term effectiveness of this modality [1,2]. Although the prognosis is expected to be good with a success rate of approximately 97-99%, but failures do occur. They are mostly attributed to the imprecise surgical or prosthodontic technique [3,4].

The first requisite to produce an accurate prosthesis is to record the intraoral relationship of the fixtures correctly. The complications usually seen are screw loosening, screw fracture, implant fracture, prosthetic-component strain and fracture and occlusal inaccuracy [5]. The Open Tray and the Closed Tray techniques are the most commonly used impression techniques to transfer the implant positions from the intraoral cavity to a working cast [6].

The closed tray technique is where the copings are manually attached to the analogs and reoriented into the impression before pouring the working cast [7]. Advocates of this technique suggest that it is more reliable as the clinician is fastening the coping to the analog under a direct vision. It's been suspected that deformation may occur when the implants are not parallel to each other [7]. The reorientation of the coping-analog assembly must be done with utmost precision and accuracy else it becomes very likely that a misfit in the prosthesis may occur [7]. On the other hand, in the open tray technique, the analogs are attached to the impression copings that have been picked up in the impression and hence are locked in the impression made [7]. It has been said that since the impression copings are directly picked up in the impression this reduces the difference in angulation, deformation of the impression material upon removal of the impression, it also reduces the task for reorientation [8]. The drawbacks of this technique are that sometimes the components may not be completely seated on the impression copings; there may be rotation of the copings while screwing the analogs into position resulting in a prosthetic misfit [9].

Different impression materials also have been proposed for making an impression [10]. The important properties of clinical interest during impression material selection are that the material should have adequate strength, be accurate, good tear strength, should have elastic properties and should be dimensionally stable. Considering all the properties, polyvinyl siloxane and polyether have been the material of choice to successfully record the implant position [11]. Numerous studies have been done in this regard but the difference of opinion over the accuracy of both when compared with each other still stands.

This study was designed to evaluate and compare the effect of closed tray and open tray impression technique with polyvinyl siloxane and polyether as impression materials on the dimensional accuracy of implant definitive casts.

MATERIALS AND METHODS

This comparative, in vitro study was conducted in the Department of Prosthodontics and Crown & Bridge and Implantology, Dr DY Patil Dental College and Hospital, Dr DY Patil Vidyapeeth, Pimpri, Pune. The samples made for the study were tested at Tata

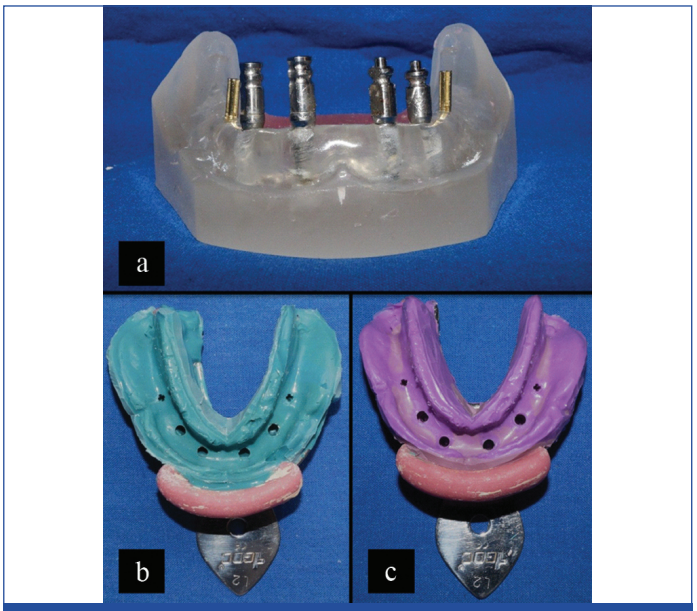
Autocomponents-Interiors and Plastic Division (IPD), Hinjewadi, Pune. The study was completed between February 2017 and August 2017. The ethical clearance required for the study was obtained by the ethical committee at Dr DY Patil Dental College, Pimpri, Pune. A total of 60 samples were made for this study and were divided into two groups. The group A comprised of 30 samples made using the closed tray technique. It was further subgrouped based on the materials used. Subgroup 1 consisted of samples made using Polyvinyl Siloxane impression material; (Express XT Putty Soft and Light Body, 3M ESPE) with n=15 and subgroup 2 consisted of samples made using polyether; (3M ESPE Monophase Polyether Impression Material-Medium-Bodied Consistency-Hydrophilic) with n=15. The group B comprised of 30 samples made using the open tray technique. It was further subgrouped based on the materials used. Subgroup 1 consisted of samples made using Polyvinyl Siloxane impression material (n=15) and subgroup 2 consisted of samples made using polyether (n=15).

The master model [Table/Fig-1] used in the study was fabricated using hard wax (Cavex Set Up Hard, Netherlands) which was poured into a standard mandibular edentulous mould. Once the wax hardened, the model was retrieved and two triangular shaped orientation grooves were made in the retromolar pad area and a third point of reference for impression tray guidance was the labial frenum. These three tray orientation points confirmed the positioning of the tray and also ensured that the impression taken was of uniform thickness. The wax pattern was then flasked and acrylised in heat activated clear acrylic resin (Pyrax Heat Cure, Roorkee, Uttarakhand, India) as per the standard protocol. Four internal connection implants (Alfa Dent), were placed in the acrylic resin model following all the norms and regulations required to place an implant. The four implants in the acrylic resin model were sequentially numbered 1 to 4 from left to right. Two metallic pins were embedded in the model approximately 10 mm away from the distal end of the last implant placed on either side. These pins acted as reference points to measure dimensions in x and y axis.

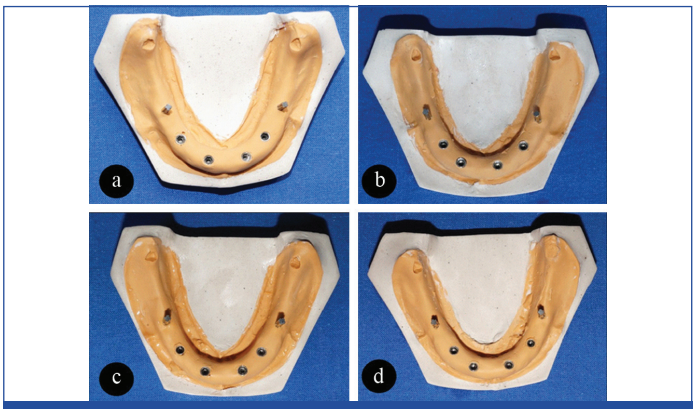
[Table/Fig-1]: Master Model.

For closed tray impression technique, impressions were made with dentulous perforated stock tray size L2 (GDC). For open tray impression technique, the corimplant lower large impression tray was used. The corimplant trays are implant stock trays made of aluminium body and are composed of seven pieces of plastic covers. These plastic covers can be detached or alternatively holes can be drilled through them to gain access to the impression coping. Both the trays were modified with cold cure acrylic resin (Dental Product of India) to ensure a definite and similar path of placement in all impressions and also to ensure a uniform thickness of the impression taken. To do so, autopolymerising acrylic resin was adapted in dough stage onto the terminal ends and around the labial flange of the tray. The tray was then seated on the master model so that the resin while in its dough stage adapted into the triangular grooves that were made in the retromolar pad area and along the labial flange of the master model and these would act as guidance for standardised tray placement.

For closed tray impression, the direct impression transfer copings were screwed into position over the implant fixtures placed in the master model using hex driver and further tightening was done with a 30Ncm force using a torque wrench. The tray was coated with tray adhesive (Medicept Dental, USA) 15 minutes before impression making. The impression material was then mixed according to manufacturer's instructions and loaded on to the tray. The complete seating of the tray was thereafter checked and the impression was taken. After the impression material was set, the impression was removed vertically along the long axis to minimise lateral stresses [Table/Fig-2]. Following this the transfer copings were unscrewed, fitted with the implant analogues and oriented in the impression. A total of 30 impressions were taken following this closed tray impression technique (15 with polyvinyl siloxane and 15 with polyether). These impressions were then poured after one hour for polyvinyl siloxane and after 30 minutes for polyether in type IV die stone (Ultra Rock, Kalabhai, India) and base formed in a standard base former mold to make the working casts [Table/Fig-3].



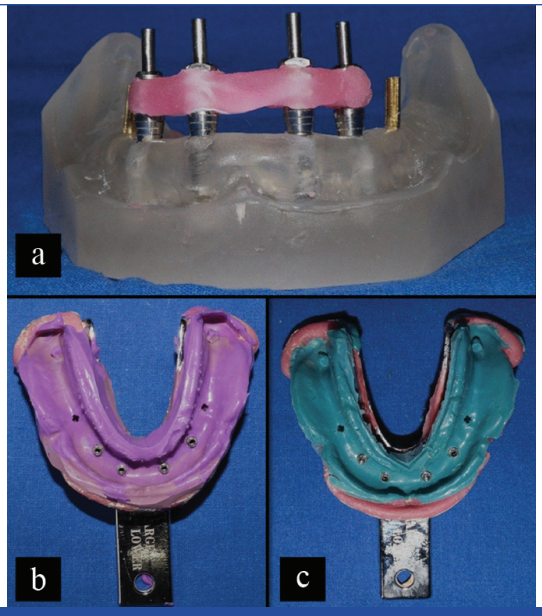
[Table/Fig-2]: Closed Tray Impression Coping on the Master model (a) and (b,c) Impression using polyvinyl siloxane and polyether.



[Table/Fig-3]: Working casts made using Closed Tray Technique with (a) PVS, (c) Polyether; and Open tray technique with (b) PVS, (d) Polyether.

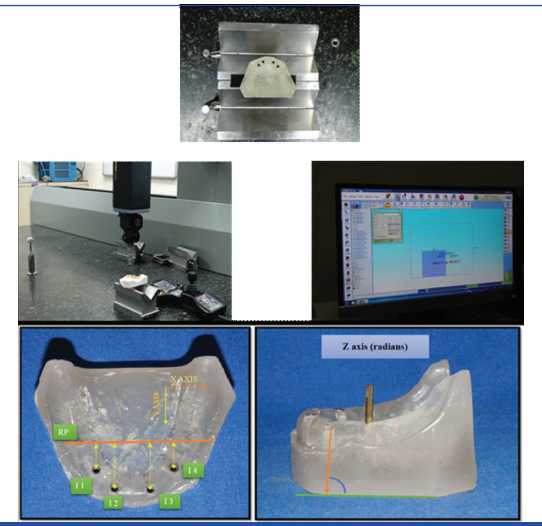
For the open Tray Impression Technique, the open tray impression copings were screwed into the implant in the master model using the hex driver and further tightening was done with a 30Ncm force using a torque wrench. They were then splinted using cold cure acrylic resin. A similar impression procedure was followed as mentioned above. Once the impression material was set, the coping screw was unscrewed. Thereafter, the copings were picked up in the impression. The implant analogues were attached to the copings that were embedded in the impression. Thirty impressions

were taken following this open tray impression technique and a similar protocol was followed as mentioned for the closed tray technique [Table/Fig-4].



[Table/Fig-4]: Open tray impression copings splinted on the master model (a) and (b,c) Impression using polyvinyl siloxaneand polyether.

The co-ordinate measuring machine (CMM): Model 10*6*6, CNC with a Reinshaw probing system (PH10 PLUS motorised probe head range) and Software-VDMIS (Virtual Dimensional Measuring Interface Standard), was used to measure the dimensional accuracy in x, y and z axis. The centre of the left metal pin was designed as the reference point for calibration of the distance changes in microns for x and y axis and radians for z axis. The base of the CMM was described as the horizontal reference plane (xy plane). An imaginary reference line was created between the two metal pins to measure the deviation of analogs. A perpendicular was drawn to the horizontal plane to check for the angulation [Table/Fig-5].



[Table/Fig-5]: Sample testing using the co-ordinate measuring machine with diagrammatic representation of the x, y and z axis.

STATISTICAL ANALYSIS

The Student's unpaired t-test was used in this study to compare the results obtained using the co-ordinate measuring machine. The p-value less than 0.05 was considered as statistically significant.

RESULTS

The results of the dimensional accuracy of each technique i.e., closed tray impression technique and open tray technique for dental implant impressions along with the impression materials i.e., polyvinyl siloxane and polyether have been enumerated in the tables [Table/Fig-6-9]. The groups have been sequentially compared according to the objectives. The student's unpaired t-test was used in this study (p>0.05) to compare the results so obtained using the co-ordinate measuring machine.

RP-I	Closed Tray impression technique using Polyvinyl Siloxane		
	X-axis	Y-axis	Z-axis
	Mean±SD	Mean±SD	Mean±SD
1	7.49±0.84	10.77±0.80	81.20±1.07
2	17.44±0.99	20.19±1.41	79.30±1.20
3	31.77±1.34	19.39±1.40	80.28±1.24
4	39.35±1.59	12.25±1.43	79.40±1.45

[Table/Fig-6]: Distribution of mean and SD values of the dimensional accuracy of impressions obtained with Closed Tray impression technique using Polyvinyl Siloxane as the impression material (RP-I: reference plane to implant) at x, y and z axis.

RP-I	Closed Tray impression technique using Polyether		
	X-axis	Y-axis	Z-axis
	Mean±SD	Mean±SD	Mean±SD
1	7.49±0.40	11.05±0.43	79.54±2.15
2	17.74±0.54	20.54±0.39	77.70±2.06
3	32.42±0.64	19.39±0.47	78.87±2.27
4	39.58±0.59	12.37±0.51	77.99±2.30

[Table/Fig-7]: Distribution of mean and SD values of the dimensional accuracy of impressions obtained with Closed Tray impression technique using Polyether as the impression material (RP-I: reference plane to implant) at x, y and z axis.

RP-I	Open Tray impression technique using Polyvinyl Siloxane		
	X-axis	Y-axis	Z-axis
	Mean±SD	Mean±SD	Mean±SD
1	7.34±0.81	11.12±0.62	79.66±1.03
2	17.52±1.09	20.35±1.21	77.71±1.03
3	31.53±1.21	19.32±1.10	79.11±1.00
4	38.89±2.41	12.01±1.02	78.90±0.73

[Table/Fig-8]: Distribution of mean and SD values of the dimensional accuracy of impressions obtained with Open Tray impression technique using Polyvinyl Siloxane as the impression material (RP-I: reference plane to implant) at x, y and z axis.

RP-I	Open Tray impression technique using Polyether		
	X-axis	Y-axis	Z-axis
	Mean±SD	Mean±SD	Mean±SD
1	7.29±0.92	11.06±0.37	80.25±1.92
2	17.51±0.36	20.43±0.22	78.54±2.07
3	31.96±0.55	19.46±0.30	79.18±1.89
4	39.48±2.41	11.91±0.49	78.73±1.52

[Table/Fig-9]: Distribution of mean and SD values of the dimensional accuracy of impressions obtained with Open Tray impression technique using Polyether as the impression material (RP-I: reference plane to implant) at x, y and z axis.

On comparing the open tray and closed tray impression technique using polyvinyl siloxane as the impression material, no statistically significant difference was observed in the dimensional accuracy of both the techniques, p>0.05. Similarly, on comparing the dimensional accuracy of both the impression techniques using polyether as the impression material, no statistically significant difference was found, p>0.05.

On comparing the dimensional accuracy of impression obtained with closed tray impression technique using polyvinyl siloxane and polyether as the impression material, no statistically significant difference was observed. Similarly, on comparing the dimensional accuracy of impression obtained with open tray impression technique using polyvinyl siloxane and polyether as the impression material, no statistically significant difference was observed.

DISCUSSION

Impressions in implant dentistry play a major role in determining the final outcome of the prosthesis. It is highly essential to have a passive and excellent fit between the prosthesis and the implant to ensure long term success of the treatment. A passive fit occurs when all the surfaces, of the implant and prosthesis, are aligned without the application of force and when the gap formed between the metallic framework and implants are within the limits established by science (111 μm) [12]. The transfer technique and impression material help the clinician to produce working casts on which an optimally adapting prosthesis can be fabricated. According to a study done by Al Quran FA et al., a clinically acceptable passive fit in the prosthesis can be achieved with closed tray, open tray splinted or open tray non splinted technique [13]. However, a relatively better fit was achieved when the open tray impression copings were splinted with autopolymerising acrylic resin, sectioned and rejoined. Even under ideal circumstances problems arising due to laboratory faults or inefficient technician skills cannot be overlooked [12]. In this study, the dimensional accuracy of impressions obtained with closed tray and open tray impression technique using polyvinyl siloxane and polyether was compared.

Cehreli MC and Akca K in 2006 carried out a study to compare the strain that was induced due to a misfit on implant supported superstructures that were fabricated using the aluminium impression caps for the open tray technique and snap on impression caps for the closed tray technique. They concluded that the closed tray technique results in acceptable superstructures, regardless of the impression material used [14].

According to Carr AB, the open tray impression technique is better as a greater inaccuracy was observed with the closed tray because of non parallel abutments and apparent deformation of the polyether impression material while reorienting the impression-analog assembly in the impression [7]. However, in the patient, the technique may be selected based on the clinical situation. For example, when the patient has limited interarch space, inadequate mouth opening, or tendency to gag the closed tray technique may be implemented. The open tray technique may be preferred in cases with multiple non parallel implants.

In this study, a total of 60 impressions were made and compared along the x, y and z axis. To measure the working casts three dimensionally, the co-ordinate measuring machine was used. The readings obtained with respect to each material and technique were first individually tabulated and compared with the master model. Subsequently, the closed tray technique and open tray technique were compared with each other using polyvinyl siloxane as the impression material first and later polyether. The study revealed that no statistical differences between the two techniques when compared with each other ($p>0.05$), was found. Few studies that showed similar results were those done by Akça K et al., Galluci GO et al., Chang WG et al., and Rashidan N et al., [15-18].

A few studies that contradicted the results of this study were those done by Hatim N et al., and Wostmann B et al., [19,20]. Hatim N et al., found that the open tray technique was considered to be better than the closed tray technique as there was a certain amount of deformation in the material when the closed tray impression coping were oriented and seated back in the impression after attaching the implant analogs to them [19]. This distortion was mainly observed with respect to the z axis. Similar conclusions were also made in the study done by Wostmann B et al., where they concluded that the pick-up (open tray) technique showed lower axis rotations as compared to the repositioning (closed tray) technique. However, higher rotational errors were observed with open tray technique [20].

The student's unpaired t-test was also used to compare the results obtained for each technique using polyvinyl siloxane and polyether as the impression material. The results revealed that there was no statistical difference in the dimensional accuracy of the impression materials when compared with each other ($p>0.05$). These results were in accordance to various other studies done regarding polyvinyl siloxane and polyether as implant impression materials.

According to Waskewicz GA et al., and Lorenzoni M et al., to achieve the best fit in the prosthesis so that it does not interfere with the path of placement, the original implant position and orientation must be reproduced on the working cast [21,22]. In between the implants, the angle of divergence or convergence may often clinically be greater than 8° or 10° [23]. Under circumstances when the implants are placed at different angles to each other the distortion of the impression material on removal may increase [24]. According to Wee AG, while making an open tray impression, the impression material must be sufficiently rigid to hold the impression coping and to prevent its accidental displacement when the analog is being attached [25]. According to the literature review done by Baig MR, both polyether and polyvinyl siloxane are the materials of choice for implant impressions and are equally good [11]. A study done by Wee AG demonstrated that study casts made using polyether and addition silicone were significantly more accurate than the casts made using polysulfide as the impression material [25]. Assuncao WG et al., also concluded that polyether and addition silicone were the best materials for making implant impressions [26].

According to a systematic review done in 2014 by Papaspyridakos P et al., the open tray technique has a higher accuracy in completely edentulous patients. However for partially edentulous patients there is no statistically significant difference between the results to suggest which technique is better and hence either the closed tray or open tray technique can be adopted. Scientific data available pertaining to the impression material of choice for implant impressions suggest that there is no difference between polyether and polyvinyl siloxane. Hence, the choice of material does not affect the accuracy of the implant impressions whether the patient is partially or completely edentulous [27].

LIMITATION

The limitations of this study were that any discrepancy occurring in the vertical direction while recording the implant position was not analysed. It only analysed the casts in x, y and z axis but the vertical movement of implants was not analysed. The non parallel implant conditions were also not analysed. Moreover, this was an in vitro study and the results may not be accurately compared with the conditions present intra-orally. Hence, further in vivo studies need to be conducted.

CONCLUSION

Within the limitations of this study, the conclusions drawn were that closed tray and open tray impressions made using polyvinyl siloxane were comparable to each other in their dimensional accuracy. Dimensional accuracy of closed tray and open tray impressions made using polyether were also comparable with each other. The results obtained did not show any statistically significant difference ($p>0.05$), though the mean values with respect to open tray technique were better. Thus, both the open tray and closed tray technique can be used based on the clinical situation and patient conditions. Additionally, the dimensional accuracy of polyether and polyvinyl siloxane was almost similar to each other when used to make impressions with closed tray and open tray technique. Thus, the choice of impression material did not affect the dimensional accuracy of the working models so produced.

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