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EFFECT OF IMPRESSION COPING SPLINTING ON IMPRESSION ACCURACY

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun 16..../03../.2018... tarih ve ...2018/06-03....sayılı kararı ile onaylanmıştır.

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Date

Signature

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DEDICATION

Above all, I thank Allah the Almighty for His endowments to me; one of which is paving my way to achieve such study. I dedicate my work to every single person who has helped me and supported me endlessly; as such, my dear family and sincere teachers. Moreover, I allot this work to everyone who has helped me in order to complete this project, at the top of the list is my supervisor.

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LIST OF SYMBOLS AND ABBREVIATIONS

°c	Centigrade/ unit of temprature on Celius scale
2D	Two dimension
3D	Three dimension
ANOVA	Analysis of variance
cm	Centimetre
min	Minute
mm	Millimetre
N.S PVS	Non Splinted Polyvinyl Siloxane
N.S PE	Non Splinted Polyether
S.N.Sec PVS	Splinted Non Sectioned Polyvinyl Siloxane
S.Sec PVS	Splinted Sectioned Polyvinyl Siloxane
B.S PVS	Splinted Splinted Polyvinyl Siloxane
STL	Stereolithography
X-axis	The first axis in the three-dimensional Cartesian coordinates
Y-axis	The second axis in the three-dimensional Cartesian coordinates
Z-axis	The third axis in the three-dimensional Cartesian coordinates
µm	Micrometre

ABSTRACT

Alem K. A. (2018). Effect of impression coping splinting on impression accuracy. Yeditepe University, Institute of Health Science, Department of prosthodontics, MSc thesis, İstanbul.

This study aimed to evaluate the effect of splinting of impression copingand different impression materials on the accuracy of multi implant impression accuraccy. A master model with four internal connection implants was prepared. Two implants placed in the canine region with 0° and 2 implants placed in thesecond molar region with 0°. Twenty five impression were performed on the master model using open tray technique (direct technique), and two different material (polyvinyl siloxane-PVS and polyether-PE). Models were divided into five groups (n=5). Two of the groups were non splinted andPVS and PE impressiom material were used in these groups. Three of the groups were splinted and PVS impressiom material were used in these groups.Models where scanned with 3D shape scanner. STL file where anaylzed and measurements where performed using 3D design program (Rhinoceros 0.5), to measure the discrepancies between the master model and the produced model. analysis of variance (ANOVA) according to Kruskal–Wallis was used. The Mann–Whitney U-test was applied for paired group comparisons (P=0.05). The results revealed that a significant difference between the splinted non-sectioned PVS and splinted sectioned PVS groups related to X axis discrepancies (P=0.030), with higher discrepancy related to splinted non-sectioned PVS technique ($\bar{x}$=46±30) µm. Also there was a significant difference between the splinted non-sectioned PVS and non-splinted PVS groups related to X axis discrepancies (P=0.014), with higher discrepancy related to splinted non-sectioned technique with polyvinyl siloxane ($\bar{x}$=46±30) µm. The best results was in 3D was with splinted sectioned PVS group with polyvinyl siloxane ($\bar{x}$=27±18) µm. The highest discrepancy among all measures recorded with splinted non-sectioned group in Z axes with ($\bar{x}$=70±70) µm. We concluded that splinting of impression copingfor a parallely placed implants doesn't affected the impression accuracy, and a better result could be reached with Splinted Sectioned Auto-polymerizing Acrylic Resin Splint Group.

Key words: Impression coping splint, impression accuracy, polyvinyl siloxane, polyether, impression technique.

ABSTRACT (Turkish)

Alem K. M. (2018). Ölçü Postlarının Farklı Splintleme Methodları İle Sabitlemenin Ölçü Hassasiyetine Etkesi, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Protetik-dis tedavisi Bölümü, Yüksek Lisans Tezi, İstanbul.

Çalışmamızın amacı, implant ölçü postlarının farklı splintleme yöntemlerinin ve farklı ölçü materyallerinin çoklu implantların ölçülerinin doğruluğuna olan etkisini değerlendirmektir. Dört adet iç bağlantılı implanta sahip bir ana model hazırlanmistir. İki adet implant kanin bölgesine 0° ile yerlestirilirken, 2 adet implant da ikinci büyükazı bölgesine 0° ile yerlestirilmistir. Ana model üzerindeiki farklı ölçü malzemesi (polivinilsiloksan ve polieter) kullanılarak toplam 25 adet ölçü gerçekleştirilmiştir. Modeller beş gruba ayrılmıştır (n = 5). Gruplardan 2'sinde implantlar splintlenmezken, diğer 3 grupta splintlenmiştir. 3D şekilli tarayıcıiletaranan modeller. STL dosyasının analizi ve ölçümleri burada 3D model (Rhinoceros 0.5) kullanılarak, ana model veüretilen model arasındaki tutarsızlıkları ölçmek için kullanılmıştır. Kruskal-Wallis'e göre değişkenlerin analizi (ANOVA) kullanılmıştır. Eşleştirilmiş grup karşılaştırmalar ıiçin Mann-Whitney U-testi uygulanmıştır (*P*=0.05). Sonuçlar, splint uygulanan kesitsel olmayan PVS tekniğine ($\overline{x}$ = 46 ± 30) µm göre daha yüksek tutarsızlık ile, X ekseni farklılıklarına (P = 0.030) ilişkin splint uygulanmış kesitsel olmayan PVS ve splintlikesitsel PVS grupları arasında anlamlı bir fark olduğunu ortaya koymuştur. Ayrıca, polivinilsiloksan (x ≥ 46 ± 30) ile splint uygulanmış kesitsel olmayan teknikle ilgili daha yüksek tutarsızlıkla, X ekseni tutarsızlıklarıyla ilişkili splint uygulanmış kesitsel olmayan PVS ile splint uygulanmamış PVS grupları arasında anlamlı bir fark vardı (P = 0.014) um. En iyi sonuç, 3 boyutlu polivinilsiloksan ($\overline{x}$ = 27 ± 18) µm olan splintli kesitli PVS grubu idi. Z ekseninde ($\overline{x}$ = 70 ± 70) µm olan splint uygulanmış kesitsiz grupla kaydedilen tüm önlemler arasında en yüksek tutarsızlık. Paralel yerleştirilmiş implantlar için izlenim başa çıkma işleminin izleniminin izlenim doğruluğunu etkilemediği ve Splinted Bölmeli Otomatik Polimerize Akrilik Reçine Splint Grubu ile daha iyi sonuca ulaşılabileceği sonucuna vardık.

Anahtar kelimeler: Ölçü postlarının splintleme, polivinilsiloksan, polieter, ölçü teknikleri.

1. BACKGROUND AND OBJECTIVES

1.1. History Of Implant Use In Dentistry

Osseo-integrated implants had believed to provided alternative treatments to teeth fixed prostheses for patients who had a missing in their teeth and achieved an acceptable long-term results (1,2). The rehabilitation of partially and completely edentulous patients with dental implants presents clinical success consistently supported by the literature. Longitudinal studies had reported an implant success rate of 80-90% in the maxilla and 96-99% in the mandible for a periods more than 15 years. Optimization of this success in fact is in direct relation to the fabrication of passively fitted implant supra-structures (3,4).

1.2. Passive Fit Restoration

It’s believed that gaining a passive fit implant retained prosthesis is a major factor in the rehabilitation success of edentulous patients. Any misfit would occur between the prosthetic parts and the implants could lead to mechanical undesired conditions such as screw loosening, bending or fracture (2,5) or other undesired biological situations namely breakdown of the Osseo-integration formed between the implant and the overlaying bone (1,6).

Accurate impression records reflect the true positions of the implants in the alveolar bone are of great necessity for a successful passive fitting (7,8). Several investigators have described the effect of accurately" paasively" fitted complete-arch fixed implant prosthesis on long-term success as seen in a comparative study made by Papaspyridakos et al (9).

According to the global clinical standard of practice, clinician's aim is to provide fixed implant prostheses which exhibit a passive fit within an accepted range when connected to multiple abutments. The ultimate contact of the internal surfaces is thought to minimize the undesired stresses and strains within the implant parts, even in prosthesis and surrounding bone in the absence of an applied external load (10,11). Furthermore, because of the ultimate fit of implant parts and the tight connection of implant to bone, small discrepancies can lead to stress could be applied within the implants when the framework is screwed down (12).

However, it is still unclear which at limit of prosthesis dis-adaptation would lead to biologic and/or mechanical complications, because the clinical fit of the prosthetic part of an implant at the implant-abutment junction has been believed to be directly dependent on the impression technique accuracy of the cast fabrication (13). Clinically, additional factors, such as number, angulations, and depth of implants somehow could affect the implant impressions accuracy (9).

A previous research stated that an absolute passive fit prosthesis in clinical practice will lead to the recommendation of sectioning then soldering of prosthesis, so by this method we can overcome the problems that come through one unit prosthesis and could be the solution of mechanical and biological problems that has been noticed in such cases (60).

One of the most precise steps for the long-term implant prosthesis success is the accuracy when we make the impression procedure which may be affected by plenty of factors such as impression technique (open-tray vs. closed-tray; splinting vs. non-splinting), impression material, impression type (conventional vs. digital) and implants angulations and number (14,15).

Numerous studies have investigated the factors that affect on the accuracy of multiple-implant conditions in completely edentulous jaws, but no specific guidelines could be clearly drawn in relation to impression making in this specific situation (13).

1.3. Aim Of Study :

The literature review identified a need for further study on the effect of impression coping splint on impression accuracy as an opposite results could be noticed. The aim of this study is to compare the effect of different techniques of impression coping splint on impression accuracy without including the other factors in the study which are believed to affect on accuracy such as implant angulation.

1.4. Null Hypothesis

1- There would be no statistical significance difference in the accuracy between models obtained from various impression material used (PVS & PE) regarding linear 3D and (X, Y, Z) axes discrepancies.

2- There would be no statistical significance difference in the accuracy between models obtained from splinted & non splinted groups.

3- There would be no statistical significance difference in the accuracy between models obtained from different types of splinting techniques.

2. INTRODUCTION

2.1. Factors Affecting Implant Impressions Accuracy

2.1.1. Factors Related To Laboratory

- Expansion of gypsum die product.
- Dimensional changes in wax .
- Framework Fabrication (58).

2.1.2. Factors Related To Clinician

2.1.2.1. Impression Materials

Besides the impression procedure is of an important step to get a an accurate impression for prosthesis making, the impression material itself plays a critical role to reach final cast accuracy. Some of the most important properties of implant impression materials should include:

For accuracy in clinical use, adequate strength is needed so it will resist breakage and tearing which may occur during removal of impression from the mouth, also has an elastic properties with a completely lack of permanent deformation due to strain and dimensional stability to get an accurate casts. Hardness is of major importance when we compare the effectiveness of impression materials in implant dentistry. Also hardness can be defined as it is a measure of the resistance to permanent deformation and could be measured as a force per unit area of indentation. Hardness of impression materials is measured using the Shore A hardness test. Impression materials that present with a high Shore A hardness number are better suited for implant impression due to increased rigidity which will decrease the amount of coping's movement (65).

The properties of an impression material has a direct effect on the implant impression accuracy, and as a result the cast implant framework accuracy. Choosing an impression material suitable for an implant–retained prosthesis specific consideration of several factors, these factors include material accuracy, clinician's experience with material that would be used, how much time would be needed before pouring, and severity of intraoral undercuts (65).

when using the pick-up implant impression technique, there would be two requirements should be taken in consideration; material should be rigid enough to withstand any minor displacement or rotation that may occur in coping during and after abutment connection hold, and should reproduce an accurate replication of implant position in the mouth to produce casts with similar analogues position for prosthesis fabrication to avoid misfit in prosthesis (8).

Wee2000, Walker et al. 2008, brought to clinician's attention the existence of a specification in marketing an impression material specific for implant impressions: Impregum Penta Soft. This material is believed to sets more rigidly than most other heavy-body impression materials used which lead to increased material resistance to distortion and flexure with coping transfer. There are however disadvantages that come with such a rigid impression material: the potential difficulty that can be notices in removing the impression out of patient's mouth due to firm contact (8,16).

In their study, investigated the accuracy of both implant impression in concern to impression technique and viscosity of impression material. They used closed tray/indirect versus open tray/ direct technique, as the heavy or medium body around the impression copings covered with medium body material. Results showed that accuracy was not affected neither by impression material viscosity nor material rigidity (16).

Liou AD et al. reported that transfer impression copings used in close technique did not return to the original position when has been replaced back in the impression for polyether or addition silicones. The results was that: no significant difference can be detected between polyether and PVS impression materials accuracy (17).

Wenz et al 2008 investigated the deviations of implant positions in either impressions or casts, in his research he used different impression materials and different techniques. Also, the relation between the distortion that occur in impression and those of the cast has been investigated. They used 2 implants parallel to each other. A pick-up technique was used with a medium viscosity material or a putty-tray material which was covered with a light viscosity injectable material; a transfer technique and a 2-step technique were used with a putty-tray material which was covered with a light-viscosity injectable material. According to the results of this study, the 2-step (PVS) method which would had been done by taking firstly a putty impression to create a space for the second impression. After that the impression is filled with light-body impression material and re-entered in the patient's mouth to get the detailed impression. The other step known as 1-step method where both putty and light-body PVS would be applied at the same time in tray then impression would be taken. Results of this study indicated that the 2-step PVS impression technique was significantly less accurate than the 1-stepputty and light-body PVS technique, medium-body PVS mono phase impression, and the medium body polyether mono-phase impression (18).

Lee et al.2008, reported in an in-vitro study that putty and light-body combination PVS impression technique was more accurate than medium-body polyether impression materi-alas the implants in this study were placed some-how deep sub-gingivally as the PVS was more flawable than PE (19).

One relevant issue that can be concluded from reviewing the literature is that different studies used different methods for analyzing distortion measurement. Nicholls 1977,stated that distortion can be absolute or relative, this definition depend on the point of reference from which the distortion had been measured (20). Barrett et al.1993, was the only study that measured absolute distortion by using an external point of reference for his measurements(21). However, the implant prosthesis connects all abutments together, so the situation here is that the strain in the prosthesis-bone interface in fact is related to the relative position of the implant abutments to one another, not as suggested by Barrett et al to an external reference point. So using relative distortion analysis in fact would provides more clinically relevant data than the use of absolute distortion analysis (22).

To summarize, it appears that various impression materials and combination of materials were tested and recommended in the dental literature. Irreversible hydrocolloid, impression plaster, polyether, condensation and addition silicones and polysulfide materials have been used in different consistencies and combinations.

Addition silicones were taught as the preferred fixed prosthodontic material which might be used in US dental schools, and recommended for implant impressions by certain studies (21,23). Polysulfide was the preferred material for removable prosthodontic material in US dental schools (24).

In recent years, improvements in physical and chemical properties regarding PE and PVS made these materials the best to choose among all other materials for implant impression making. Many researchers have evaluated implant impression accuracy and found better results with PE and PVS versus condensation silicone, polysulfide, irreversible hydrocolloid and plaster materials (4,19).

Among the analyzed papers, the results of most these studies reported no difference between PE and PVS (3,4,47,21,68,67,69,66,41,8,18), while Del'Acqua et al. 2010, reported better accuracy with PE (12).

A systematic review made in 2014 by Papaspyridakos et al. concluded that the best accuracy of implant impressions could be gained when either (PE or PVS) were used in implant impression making for completely edentulous patients as they produce the minimum distortion among all other type of impression material (13).

2.1.2.2. Open Tray vs. Closed Tray Impression Techniques

In dental practice there are two traditional methods for impression taking namely :

1. The pick-up (open tray) technique which involves fastening an impression coping to the implant with a screw that extends above the height of the coping and through an opening cut in a custom impression tray (also called direct technique). The screw is loosened when the material is set and the tray is removed from the mouth with the impression coping retained within the impression. An implant analog is fastened to the impression coping using the same screw and a working cast is poured (25).

In the pick-up technique, the impression coping would be remained undisturbed in the impression which would reduce the chance of impression distortion that may occur during tray removal from the mouth due to implant angulations or wrong path of tray dislodgement, and avoid the need to replacing the coping back into its respective space in the impression with chance of mal-positioning. Although this technique seems to be perfect but in fact it has some disadvantages as there might be some rotational movement of the impression coping when extra force would be applied during the securing of implant analog, and blind attachment of the implant analog to the impression coping as x-ray couldn't be taken to ensure accurate fitting may result in a misfit of components (25).

2. The transfer technique uses tapered copings without any undercuts and a closed tray with no openings in tray for coping unscrewing to make an impression (also called closed tray or indirect technique). The copings would be screwed to the implants, then an impression would be made, after material setting, the tray would be recovered from the mouth without unscrewing so leaving the copings intraorally.

The copings would be removed and connected to the implant analogs, and then the coping with analog connected to it together would be re positioned back in the set impression, after that pouring of impression to gain a definitive cast. In practice some clinical situations such as limited mouth opening, a tendency to gag, or some posterior implants difficult to access, a closed tray technique would be helpful and much easy to be performed (17).

Supporters of the closed tray technique suggest that the visual fastening of implant analog and ability to take an x-ray for coping after placing in mouth would ensure correct positioning of components, as a result more accurate casts could be produced. There is concern that inaccuracies could be noticed with recovery and subsequent deformation especially with angulated implants or patients with restricted mouth opening may be encountered. Impression copings repositioning must be accurate, if not, misfits would occur (25).

Carr et al. in 1991, used a five-implant edentulous mandibular master cast with inter-abutment divergence angles of less than 15 degrees. The authors used transfer technique with tapered copings and a pick-up technique with square copings, all impressions were made with polyether material. The results showed that the pick-up method provided the most accurate working casts (25).

Carr et al. in 1992, used a two-implant model represented by an anterior implant parallel to the adjacent natural tooth and a posterior implant exhibiting a 15 degree lingual inclination. The authors investigated the accuracy of the transfer and pick-up technique using polyether impression material. The results showed that the pick-up technique showed comparable or better results than the transfer technique. Also, a less than 15 degree divergence between implants in the same arch segment did not seem to play a great role in impression accuracy for implants in close proximity (26).

Herbst et al. 2000, investigated implant impressions which were made using four techniques: in the first group a tapered impression copings not splinted was used, for the second group a squared impression copings not splinted, the third group used splinted squared impression copings by duralay acrylic resin, and for the fourth group a modified squared impression copings as it has a lateral extension on one side without the use of splint. The impression material used in all groups was additional silicone. The open trays technique were used for the squared copings besides closed trays for the tapered copings, there weren't any angulations between implants as a complete parallelism was performed. The end results of this research was that there was not significant difference could be detected between the four techniques (27).

De La Cruz et al.2002, examined the dimensional accuracy by comparing verification jigs accuracy with that of conventional impression procedures that doesn't use such jigs, three resin materials used to fabricate verification jigs were examined: GC pattern resin, Duralay resin and Triad gel resin. Three parallel externally hexed Steri-Oss implants were used and two types of impressions were made, transfer impression copings and pick-up impression copings. Results showed that the use of verification jigs has no superior advantage to standard impression procedures. Also stated that jig fabrication did not improve the dimensional accuracy of stone casts suspected, while Pick-up impressions showed a significantly greater inaccuracy in regard to the vertical plane (28).

Daoudi et al. 2004, investigated the effect of repositioning the copings by different skilled people as he mentioned in his study that more skillful operator has a great chance to reposition the transfer more accurately than unskilled operator. In his study he divided the groups as dental students, postgraduate, senior dentists, and dental technicians.

The end result showed that the copings never returned to the original position, as this factor could be of a major source of error in the transfer impression technique. This amount of inaccuracy could be multiplied in cases where multi-implants would be transferred (29).

Conrad et al.2007, used four implants in his study with different angulations to measure the accuracy of the transfer/close technique and pick-up/open implant impression techniques. One implant was perpendicular to the horizontal plane of the working cast while the other three implants had 5, 10, or 15 degrees convergence or divergence. The average angle errors for the transfer and pick-up implant impression techniques did not show divergent results when compared to the master cast, with no statistically significance results. As a result of this study the conclusion was that an angulations within 15 degree does not affect implant impression accuracy (30).

Walker et al 2008, investigated the effect of impression technique and impression material viscosity combinations on implant impression accuracy. In this study they used transfer/close technique with plastic impression caps versus pick-up/open implant impression technique. Abutment level implants were used and a medium body PE as an impression material. Results showed that more accurate casts could be obtained with close/transfer implant impression technique when plastic caps where used than the pick-up technique (16).

Wenz et al. 2008, used two implants parallel to each other to investigate whether transfer or pick up technique has an advantage upon cast accuracy. A pick-up technique was used with a two step PVS impression material, a transfer technique was used with the same material to excluded material effect. Results were that both techniques could produce casts would used to fabricate prosthesis that give a successful clinical results without misfit and with no significance difference between them (18).

2.1.2.3. Angulations Of Dental Implants

In clinical practice as a result of getting restoration which aremore functional and more esthetical to perform patient's expectations, an angulated implants has came to be applied. The position of implant should follow the anatomy of residual ridge in most of cases, also the atrophy of bone obligate the application of a severe angulated implants like in zygomatic implant. The UCLA abutment was firstly fabricated in the laboratory to improve the esthetics of implants retained prosthesis (31).

The lack of parallelism in implants creates an undercuts which makes tray recovery may lead to impression distortion that produce an inaccurate master cast, especially with the closed tray technique. If multiple implants were surgically placed at different angles, the distortion of the impression material upon tray removal would be increase, especially if large number of implants were used. Two studies used 4 and 5 implants with more than 15 degree angulations found that casts with angulated implants produce more discrepancies than casts with straight implants (25,32).

Two other studies that used 2 or 3 implants couldn't find any effect for the angulations on impression accuracy as they stated that angulations itself with a few number of implants didn't affect accuracy (33,30).

Carr et al. 1992, evaluated the accuracy of casts fabricated from impressions using two different transfer copings in a 15 degree divergent two implant in posterior mandibular model. One implant was parallel to the adjacent natural first premolar and 11 mm apart from the second implant which exhibited a 15 degree lingual inclination. The authors investigated the accuracy of the transfer vs. pick-up technique using polyether impression material. The results showed that the pick-up technique showed comparable or better results than the transfer technique. Also, a less than 15degree divergence between implants in the same arch segment did not seem to play agreat role in impression accuracy for implants in close proximity (26).

Assuncao et al. in 2004, evaluated the effect of various implant angulations on the accuracy of implant impression transfer under different parameters: transfer technique with conical copings, pick-up technique with square copings and square copings splinted with duralay acrylic resin. The angulations were 0, 10, 15 and 25 degrees in relation to a perpendicular line on the horizontal matrix surface. The most accurate results were obtained for the implants situated at 0 degrees and the worst results were obtained for the implants at 25 degrees to the horizontal. This study proves that the accuracy of implant impressions decreases with the angulations of implants (32).

Conrad et al. measured the accuracy of implant casts when implants that had 5,10 or 15 inclinations from each other. They tested various impression techniques open versus close and both PE & PVS impression material were tested in this in vitro study and stated that no significant difference could be noticed among the tested groups (30).

Assuncao et al. 2008, had investigated three different impression techniques for two external connection implants with two different inclinations: one perpendicular to the horizontal plane and the second implant inclined by 25 degrees from first implant. A square copings was used in all three groups where the first group was splinted with acrylic resin, the second group was splinted with prefabricated acrylic bar and a non splinted third group as the coping here air-abraded with aluminum oxide.PE was used in three groups. Results: the non-angulated implants provided more accurate casts than the angulated implants which supports the idea that a more than 15 degree angulated implant would give a less accurate casts (34).

Filho et al. 2008, compared splinting effect on impression accuracy when the implants were put in an angulated way as he used two implants, one with zero degree and other with 25 degree to a perpendicular line on horizontal plane. The result of this study revealed that implants splinted with prefabricated acrylic resin bar would produce more accurate casts than un-splinted as the angulated implant in non-splinted group recorded a high amount of deviation than the angulated splinted implant (35).

Several studies have focused on the effect of implant angulations on impression accuracy. Implant angulations from 10 to 30 degrees convergence and divergence have been tested. Three studies agreed that as much as inclination increases as the accuracy decrease (32,34,35). No angulations effect on accuracy (26,30). Lee et al. 2008, stated that more studies are needed to detect angulations effect on accuracy (19).

2.1.2.4. Splinted vs Non-Splinted Technique

The distortion of abutment positions is very common with available impression techniques. Mostly the rotation of implant coping during analogue fastening is believed to cause impression inaccuracy, and for that reason splinting of coping before impression taking was introduced and believed by some authors to minimize rotational effect.

Branemark et al. 1985, stated that of a clinical importance, the impression copings should be splinted to prevented any expected rotation, he suggested the use of auto-polymerizing acrylic resin in splinting over a scaffold of dental floss connecting impressions posts together to prevent coping movement during impression-making and analogue screwing procedure (40).

Akalin et al. 2013, Lee et al. 2008, stated that splinting the copings with a rigid material has been advocated as a technique to prevent individual coping movement and proved to give a better results and more accurate casts than those non-splinted coping especially with angulated implants and wide ridges (4,19).

Splinted copings gave a more accurate casts than those non-splinted impression copings for patients who had lost their all teeth was the conclusion of a systemic review made by (Papaspyridakos et al. 2014) (13).

Some authors didn't agree with splinting with the possibility of distortion of the splint materials (Spector *et al.*, 1990) (41), connection fracture between copings and the splint material (Burawi*et al.*1997, Moreira et al. 2015)(42,15).Sectioning of the splint before complete setting of the material then reconnecting the sectioned part to avoid such problems and avoid the effect of material shrinkage on coping position (43).

Humphries et al 1990, investigated the dimensional accuracy of master casts fabricated using tapered copings group and squared copings group not splinted together and the third squared group has been splinted with acrylic resin. A parallel four implant model was used. All impressions were made in custom trays with a two-stage addition-reaction silicone material. Results showed that the un-splinted tapered coping technique, gave more accurate results than the un-splinted and splinted squared polymer coping techniques (46).

Assif et al.1992, also investigated the accuracy of implant impression procedures using four techniques and a different measuring scheme from the previous investigators. The results indicated an advantage with the splinted pick-up copings. Data showed that the splinted coping/ alginate group and the splinted coping/ polyether group were most accurate, followed by the un-splinted coping/polyether group and the tapered coping polyvinyl siloxane group (43).

Barrett et al. 1993, evaluated six impression techniques: tapered copings with alginate and polyvinyl siloxane, square copings with plaster, polyether and polyvinyl siloxane, copings were splinted with floss and acrylic resin before making the polyvinyl siloxane impression. This project introduced a new design to measure absolute distortion by using three widely separated reference points outside the distorting medium. Result: No significant differences were noted among the materials used for the square copings. Tapered impression copings produced less accurate results than squared copings. Splinting the copings with acrylic resin produced better results than non- splinting (21).

Hsu et al.1993, compared the accuracy of polyether impressions made by four techniques: non-splinted square copings, dental floss and duralay resin splinted copings, stainless steel orthodontic wire and duralay splinted copings and copings splinted using prefabricated blocks of duralay. The study concluded that the bulk volume of duralay acrylic resin used for splinting is an insignificant factor in impression transfer accuracy, there was no significant difference between the splinted and non-splinted copings (44).

Phillips et al. 1994, compared the accuracy of three implant impression techniques using tapered copings, square copings alone and square copings with acrylic resin splint. The implant replicas had a 10 degree angulations toward the labial. The authors found-out that there was no significant difference between the splinted vs. non-splinted technique accuracy as well as between square and tapered copings. However, authors consider the splinting technique to be lengthy, complicated and not more accurate than the non-splint technique and therefore unnecessary (59).

Assif et al. 1996, assessed the accuracy of three impression techniques: non-splinted square copings, copings splinted with auto-polymerizing acrylic resin and copings splinted directly to an acrylic resin custom tray. The authors used five parallel implant analogs in a mandibular master cast. The technique using acrylic resin tosplint the transfer copings produced better casts than the two other techniques (45).

Burawi et al.1997, used five implants in his study to compare the dimensional accuracy of a splinted impression copings and compared it with another non-splinted group. The splinted technique showed more deformation than the un-splinted technique as he used auto-polymerizing acrylic resin not sectioned for the splinted group, and stated that shrinkage of acrylic would cause deviation in copings and should not be used (42).

Herbst et al. 2000, investigated implant impressions which were made using four techniques: In the first group a tapered impression copings not splinted was used, for the second group a squared impression copings not splinted, the third group used splinted squared impression copings by duralay acrylic resin, and for the fourth group a modified squared impression copings as it has a lateral extension on one side without the use of splint. The impression material used in all groups was additional silicone. The open trays technique were used for the squared copings besides closed trays for the tapered copings, there weren't any angulations between implants as a complete parallelism was performed. The end results of this research was that there was not significant difference could be detected between splinted and non-splinted groups (27).

Vigolo et al. 2003, used polyether impression material in comparing the accuracy of three different impression techniques. In the first group non-modified square impression copings were used; in the second, square impression copings were used and joined together with duralay acrylic resin just before the impression procedure; and in the third, square impression copings, previously air-borne particle abraded and coated with the manufacturer recommended impression adhesive were used. The best results and more accurate cast replication could be gained by the square impression copings joined together with duralay acrylic resin also the square impression copings group which air-abraded and adhesive where applied on it (48).

Vigolo et al. 2004,used polyether impression material in comparing the accuracy of three different impression techniques when the implant would be placed deep sub-gingivally. The authors used a connection system that had a 4-mm–deep internal lock with thick walls . Results: The splinting of coping in this situation has an advantage effect on the accuracy of casts produced on the non-splinted, air–abraded, adhesive-coated impression copings groups that had been tested in study (49).

Assuncao et al. 2004, investigated the effect of various implant angulations on the implant impressions accuracy under different parameters: transfer technique with conical copings, pick-up technique with square copings and square copings splinted with duralay acrylic resin. They investigated also four types of impression materials: polysulfide, polyether, addition silicone and condensation silicone. Results: The splinted technique showed better accuracy (32).

Kim et al. 2006, investigated the accuracy of the implant impression with use of many different laboratory procedures in pouring and splinting, the end result of his study was that non-splint technique produces more accurate casts when splinting was applied during the impression-making procedure, while more accurate casts were produced with the splint technique in cases where splinting was done during the cast fabrication procedure (50).

Assuncao et al.2008, compared three different impression techniques for two external connection implants with two different inclinations: First implant perpendicular to the occlusal surface and the other with 25 degrees divergence to first implant. Polyether impression materials were used for the three impression techniques: square impression copings splinted with acrylic resin, square copings splinted with prefabricated auto-polymerizing acrylic bar and non-splinted square copings applied to air-abrassion. Results: showed that the non splinted group produced casts that were less accurate than the splinted groups (34).

Cabral &Gudes2007, investigated the following four techniques: a transfer impression technique with tapered transfer copings, a pick-up impression technique with un-splinted squared copings, a pick-up impression technique with square copings splinted with duralaya crylic resin, and a pick-up impression technique with square transfer copings with duralay acrylic resin splints sectioned after complete setting of the material and then reconnected with same resin material to overcome the shrinkage effect of resin material. The best results regarding cast accuracy could be gained by the group where the copings had been splinted then sectioned and reconnected by the same resin material (51).

Choi et al.2007, used two implant level implants in his evaluation of accuracy and divided their groups as: one pick-up non-splinted (square impression copings) and one splinted (square impression copings splinted with duralay acrylic resin), and used custom trays in impression taking for all the samples. The implants were put as one perpendicular and the other one was 8 degree divergent from the first implant using a laboratory model. The non-splinted and splinted techniques didn't show any variations on cast accuracy and splinting doesn't seems to have an advantage effect on accuracy with divergence up to 8 degrees (33).

Filho et al.2008, tested the effect of different coping splinting techniques upon impression accuracy, in this study the implants where put in different angulations, and an open/pick up technique was used in all groups with use of PVS impression material. Results: When copings were splinted with a prefabricated acrylic resin bar, the accuracy of casts produced by this technique showed better results than other splinting techniques (35).

Some studies showed no difference between splinted and non-splinted (27,44,33,50,59). Most studies favored the splint technique (21,32,34,35,43,45,48,49,51),while others showed more accurate impressions with the non-splint technique (42,46).

Although there was no consistent result regarding the advantage effect of when compared to the non-splint technique as it could be affected by the other factors as implant angulations and depth of placement, more studies favored the splint technique as being more accurate for implant impressions.

2.2. Splint Material

Poly methyl methacrylicate (PMMA) auto-polymerizing acrylic resin has been used by many studies and considered to be as the splinting material of choice and different techniques have been tested, such as prefabricated acrylic resin bars connected to copings either sectioned and reconnected or not, and stainless steel burs connected to coping by acrylic esin (36,37), however minimizing the shrinkage of the acrylic resin still of an argument between researchers (19).

In a previous study, the author found that the mass of acrylic influence the accuracy as they stated that the larger the acrylic mass will be the larger the inaccuracy and advised the sectioning and soldering of acrylic to overcome this effect (52).

Mojon et al 1990,stated that (80%) of the shrinkage occurred within the first 17 minutes after the starting of material mixing with a total amount of polymerization shrinkage reaches between 6.5% and 7.9% within 24 hours (53).

2.3. Other Factors May Affect Impression Accuracy

2.3.1. Coping Design Internal vs. External Connection Of Dental Implants

Many kinds of abutment connection have been introduced to dental clinical practice, such as external hexagon, internal hexagon and taper joints. The implant external hexagon design was first introduced by Brånemark 1985 (40).

Taylor & Agar in 2002,stated that after the use of external implant/abutment connections a new concept of connection has been introduced which is internal implant/abutment connection that differs upon external hex in terms of size, surface area and geometry (54).

Another type of connection has been introduced which is the taper joint connections. This type is believed to has a conical seal or Morse's taper, which has an advantages sealing capabilities and can seal the micro-gap in a better way than those in other connection types (56).

Vigolo et al. 2004, used a connection system that had a 4-mm–deep internal engagement that ensure a complete and a proper seating of different components. A pick up/direct impression technique was used which will obligate coping removal to investigate the effect of stresses produced during coping removal upon coping stability within the impression. The study hypothesized that a higher level of stress could be occur between impression material and impression copings when copings were unscrewed and removed from internal connection implants if the internal hex was deep and a tight lock between abutment and implant was achieved, and he stated that splinting of copings with acrylic resin could prevent stresses produced to affect the stability of coping inside the impression (49).

There are lack of researches that had compared the effect of internal connection to the external connection as most of studies used one connection type in their study, so data cannot be compared (Papaspyridakos et al., 2014, Gracis et al., 2012) (13,56).

2.3.2. Depth Of Implant Placement

For some esthetic demands or where bone loss is expected, clinician may place the implant in a deep sub-gingival position to accommodate his needs; in these cases when an implant impression would be taken, a part of the coping would be fallen under the gingival level. This fact was thought to affect on coping stability inside the impression and had been tested by some researchers.

Lee et al. 2008, investigated the effect of implant placement depth on the accuracy of the implant impression. The authors used five parallel implants and two types of impression materials: polyether and polyvinylsiloxane. One implant was placed 2 mm and one 4 mm below the top surface of the model. The results of this study revealed that when PVS impression material was used there was no effect on accuracy for implant depth, but when a medium-body polyether impressions was used, the shallower implant exhibit more accurate accuracy than the deeper implant (19).

2.3.3. Impression Tray Type (Stock/Custom Tray)

Too few studies were available, so no clear conclusion can be drawn about the effect of tray type, besides some authors hypothesize the try type as a factor.

2.3.4. Machining Tolerance

Phillips et al.1994, compared the accuracy of three implant impression techniques using tapered copings, square copings alone and square copings with acrylic resin splint. Distortion values were compared to the known machining tolerances for these copings. The distortion of the non-splinted square copings was the only one that showed no significant difference when compared to the measured machining tolerance (59).

2.3.5. Pouring Technique

Del Acqua et al.2008, compared 3 pouring techniques: Conventional pouring, in the second group he used latex tubes fitted onto analogs before pouring to minimize expansion effect of stone on coping position, and in the third group he splinted the analogues by acrylic resin before pouring to prevent analogue movement. Four implants were positioned in a mandibular cast for accuracy assessment. Polyether impression material was used for all impressions. The most accurate pouring technique could be recorded when a latex tubes where used (57).

3. MATERIAL AND METHODS

Table 1. Table summarize the used materials and devices in this study

	Materials and devices	Manufacturing details
1	4.3*10 internal connection implant	Implance Ltd, Trapzon Turkey
2	Rubber model former	One Dental Pty Ltd,New South Wales, Australia
3	Epoxy Resin	Epoxy Resin, Torrdental Ltd, Turkey
4	Parallelometer	Bego Gmbh, Bremen, Germany
5	BICP45L Hex Impression coping pick up	Implance Ltd, Trapzon Turkey
6	Cavex Ste Up Regular Wax	Cavex Gmbh, Haarlem, Holland
7	Alginate impression	Tropicalgin, Zhermack SpA ,Badia Polesine Italy
8	Metal impression tray	GC America INC, USA
9	Dental stone type IV	Dentona Gmbh, Dortmund, Germany
10	Stone vacuum mixer	Smart-Mix, Amanngirr-Bach Gmbh, Pforzheim, Germany
11	Vibrator	Whip mix corporation, louisville, USA
12	Nova- Tray Light Curing Tray	President Dental Gmbh , München,Germany
13	Triad 2000 Visible Light Curing Unit	Dentsply International,York Pennsylvania USA
14	Ratchet With Torque	Implance Ltd, Trapzon Turkey
15	Polyvinyl siloxane adhesive material	Zhermack SpA , Badia Polesine Italy
16	Polyether adhesive material	3M ESPE Corporate, St. Paul,USA
17	Additional silicon impression material	Express Xt Penta Putty Soft, Express Xt Light Body Quick, 3M ESPE, Corporate, St. Paul, USA
18	Garant dispenser	3M Corporate, St. Paul, USA
19	Polyether impression material	3M ESPE Corporate, St. Paul, USA
20	Auto mixing machine	3M Corporate, St. Paul, USA
21	Disposable 10ml plastic syringe	Agar Scientific, United Kingdom
22	BFLA Implant Analogue	Implance Ltd, Trapzon Turkey
23	Cold acrylic resin	GC Corporation, USA
24	Diamond disc	Mend Tech Inc, USA
25	Prefabricated acrylic resin bar	Bego Gmbh, Bremen, Germany
26	BORA60, O-Rings Abutments	Implance Ltd, Trapzon Turkey
27	3D scanning machine	3Shape 3E Lab Scanner Inc, Copenhagen, Denmark

3.1. StudyDesign

A maxillary acrylic cast with four bone level implants(Table 1. Line 1) were placed to simulate a common clinical situation, all implants were parallel to each other and perpendicular to the horizontal occlusal plane, two implants were inserted in the canine region and the other two implants were inserted in the second molar region, two reference points (3mm-radius round screw)has been fixed on the master model for repeatable super-imposition of all models.

The study has compared the discrepancies in (X, Y and Z axes) and 3D changes of five groups in relation to the master cast. All impressions were done using open “pick up” impression technique, while the groups were as below :

1)**N**on-**S**plinted group using **P**oly **V**inyl **S**iloxane impression material (**N.S PVS**).

2)**N**on-**S**plinted group using **P**oly **E**ther impression material (**N.S PE**).

3)**S**plinted **N**on-**S**ectioned group using duralay acrylic as a splint and **P**oly **V**inyl **S**iloxane impression material (**S.N.Sec PVS**).

4) **S**plinted-**S**ectioned group using duralay acrylicas a splint “sectioned then reconnected”

And **P**oly **V**inyl **S**iloxane impression material (**S.Sec PVS**).

5)**B**ar **S**plinted group which uses acrylic bar joined to the impression post by duralay

Acrylic and **P**oly **V**inyl **S**iloxane impression material (**B.S PVS**).

- Five impressions (n=5) for each group will be taken using custom tray and poured using(Type Four Improved Dental Stone Germany).

3.2. Fabrication of the reference model (Master Cast)

A prefabricated rubber model former for edentulous upper jaw (Table 1. Line 2), was used to fabricate the master cast (edentulous maxillary arch) where auto-polymerizing epoxy resin (Table 1. Line 3), has been mixed in a rubber bowel and poured into the rubber former then allowed to set according to manufacturer instructions. After setting of the poured cast it has been removed from the rubber model former and a maxillary master cast was already fabricated.

The master cast was held in a vertical parallelo-meter milling machine(Table 1. Line 4) (Figure 1), and holes matching the depth and diameter of the implants has been made, two in canine regions and two in second molar region, the four implants has been placed into the master cast within the prepared holes (Figure2).

To standardize measurement of all models in five groups, two reference points (3mm-radius round screw)has been fixed on the master model. Where the first reference point has been inserted in the alveolar crest of the master model on the incisive papillary region perpendicular on the horizontal plane, the other reference point in median palatine suture posterior to a line crossing the posterior implants (Figure 2). These points will be used in measurement procedures as a reference points.

Three grooves "stops" with 3-mm deep 6-mm width and 8-mm height (one anterior and one in each posterior side in the sulcus area of the cast), to ensure repeatable and accurate repositioning of the custom impression tray (Figure 3).

Impression posts for pick up technique (Table 1. Line 5) was connected to each implant and torqued at 10 Ncm. So the reference model resembles a maxillary screw-retained implant-supported fixed complete denture situation.

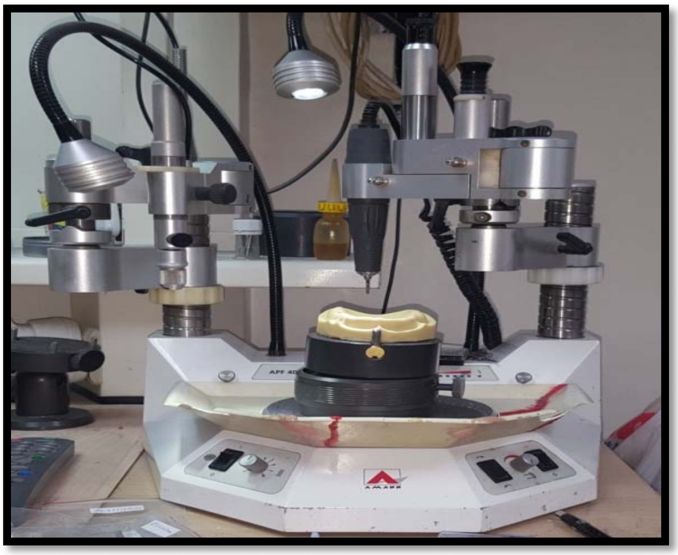


Figure 1. Parallelometer milling machine used for parallel placement of implants

Figure2. Master model with four parallel implants shows reference points for measurement standardization

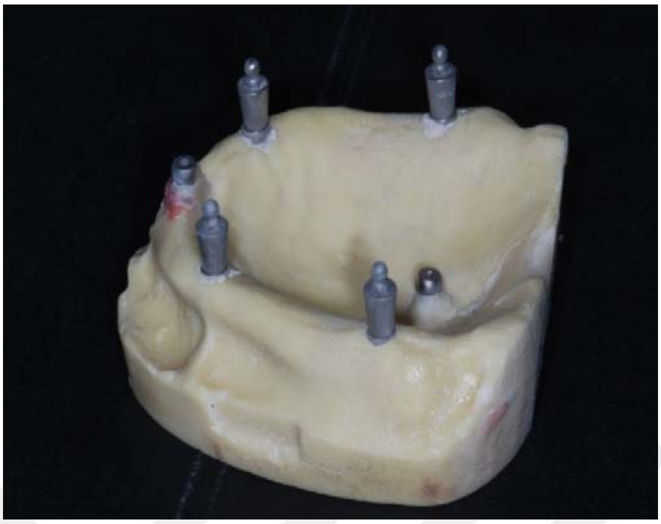


Figure 3. Master model shows grooves on the side for repeatable repositioning of the custom impression tray

3.3. Custom tray fabrication

Three layers of modeling wax (Table 1. Line 6) has been carefully adapted onto the model, while the impression posts were loaded, to produce a space for impression material (Figure 4) then impression was taken with an alginate impression (Table 1. Line 7) using a ready-made metal tray (Table 1. Line 8), extended with wax to reach the periphery of the master model (Figure 5).

This procedure was done twice to produce two different spaced models which will be used for fabrication of custom trays. For the splinted groups, the distances between the impression posts were filled with modeling wax up to screw level to get a space for the future applied splint, but for the non-splinted groups, this distances weren't filled.

The alginate impressions has been poured with improved type IVdental (Table 1. Line 9) to obtain a spaced primary casts, a mechanical vacuum mixer (Table 1. Line 10), was used at 425 RPM and mixed for 30 seconds, as recommended by the manufacturer. The stone was poured on a vibrator (Table 1. Line 11) to minimize the entrapment of air bubbles, then it was allowed to set for one hour.

The resulting spaced casts have been used to fabricate the custom trays. Twenty five custom trays (one use for each tray) measuring 2mm in thickness and with four windows corresponding to the sites of implants has been constructed.

Figure 4. Modelling wax adapted to model to fabricate special tray

Figure 5. Wax extention for metal tray for alginate impression

Figure 6. Special tray perforations & tray stops

The trays has been made from a visible light-polymerizing material (Table 1. Line 12), which was carefully adapted to the spaced casts and polymerized (Table 1. Line 13), for a total of 6 minutes as indicated by the manufacturer.

Three stops that were made in the land area of the reference model to ensure repeatable and accurate repositioning of the custom impression tray were duplicated in the tray, the trays were perforated to aid in mechanical retention of impression material(Figure6), and left for 24 hours undisturbed before use to ensure dimensional stability.

3.4. Impression Procedures

Impression coping for pick up technique (Table 1. Line 5)were placed on the reference model and tightened up to 10 Newton using ratchet (Table 1. Line 14) to the implants on the reference model.

The inner surface of all the trays was coated with a suitable adhesive according to the impression material would be used (Table 1. Line 15) for PVS impression, and (Table 1. Line

16) for PE by using a brush (Figure7). Warmed boxing was adapted over the openings before loading the tray with impression material, after the tray has been seated, the base plate wax has prevented the flawing of impression material through the openings and also helped in identify the location of the impression copings.

All of the impressions were made in a temperature-controlled environment (23° C). The impression material polyvinyl siloxane (Table 1. Line 17), was used according to manufacturer's instructions. The putty impression material was manipulated for 30 seconds and was placed on the tray. The manufacturer's setting time was doubled to compensate for delayed polymerization reaction at room temperature. Simultaneously, light body material was injected around the coping and the putty loaded tray using dispenser (Table 1. Line 18), then tray was positioned on the master cast and a finger pressure is applied over the tray until the stoppers get in place for 8 minutes from the starting of impression manipulation (Figure 8).

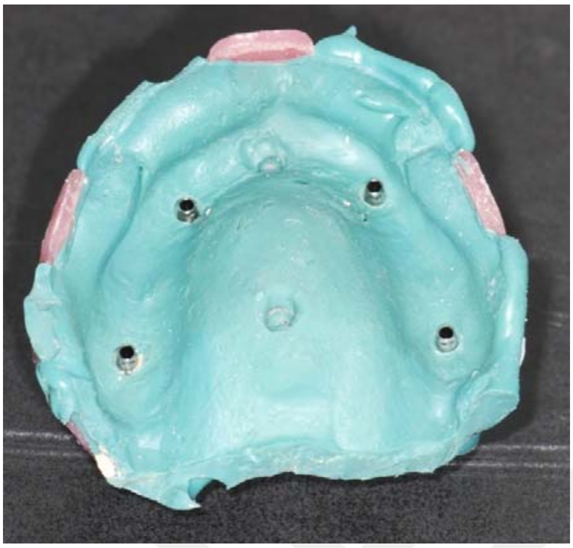
Figure 7. Application of Polyether adhesive material and polyvinyl siloxane adhesive material.

Figure 8. Tray stoppers get in model grooves

For the second group, polyether (Table 1. Line 19) was used to make the impression. Auto mixing machine (Table 1. Line 20) has been used to mix the impression material, then a 10 ml plastic syringe (Table 1. Line 21) was used to inject the mixed medium body PE impression on the model to cover the implant copings and reference points. Then tray was positioned on the master cast, a finger pressure is applied over the tray until the stoppers get in placefor 8 minutes from the starting of impression manipulation.

After complete setting of the impression material, the copings was loosened with a driver and removed, the tray was separated from the master cast while the impression copings remained locked in the impression (Figure 9).

The guide pins was placed back into the open tray impression copings from the top, while an implant analogs (Table 1. Line 22) were connected to the hex and the guide pins were hand tightened and left undisturbed for 2 hours (Figure 10).



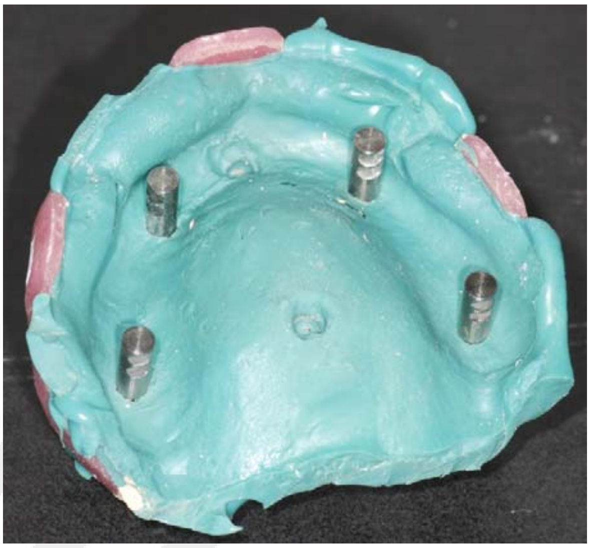


Figure 9. PE impression showing analogue **Figure 10.** Analogue tightened to copings

3.5. Splinting Criteria

1) For Splinted Non-Sectioned duralay acrylic group GC Pattern Resin (Table 1. Line 23), was directly applied to the sides of impression coping after connecting the coping with dental floss (Figure 11), until all the impression posts were splinted with acrylic to make a continued regular splint about 4mm in diameter (Figure 12), then left to polymerize for 20 minutes before impression procedure to avoid taking impression during the peak phase of acrylic shrinkage (53).

2) For Splinted-Sectioned duralay acrylic groups: In order to resemble a clinical situation, the impression copings were seated to the implants of the master cast and hand-tightened, a primary impression were taken using close tray/indirect technique. After pouring, the impression coping were tightened to the resultant cast and were connected together by dental floss, then a Pattern Resin (Table 1. Line 23) was applied over the dental floss and around the impression copings to make a continued regular splint about 4 mm in diameter.

After polymerization of duralay acrylic, the splint has been sectioned between implant posts using a diamond disc (Table 1. Line 24) (Figure 13), and the copings was loosened with a driver and removed after numbering the sectioned parts starting with N 27 implant ending with 17 (Figure 14).

This procedure has been done five times to produce jigs for five sample models. The sectioned parts for the same splint were put in a separate pouch. The sectioned parts has been joined 24 hours later(as mentioned above to resemble a clinical situation where splint would be made at dental lab and being send to the clinician)with freshly mixed duralay acrylic using brush bead method then left to polymerize for 20 minutes before impression procedure (Figure 15).

3) For the acrylic bar and duralay acrylic splinted group, a prefabricated acrylic resin bar (Table 1. Line 25)was cut to pieces according to distance between the implants “0.5 mm shorter from each side“ using a diamond disc (Table 1. Line 24)then joined to coping using brush bead method for applying Pattern Resin (Table 1. Line 23) (Figure 16), then left to polymerize for 20 minutes before impression procedure.

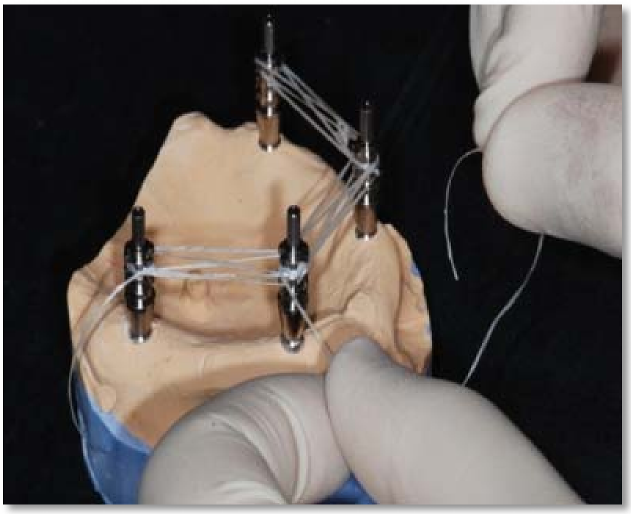


Figure 11. Copings connecting with D.floss

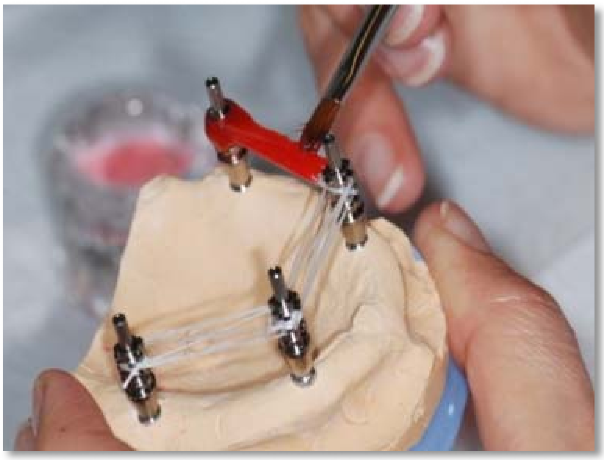


Figure 12.GC acrylic application over D.floss

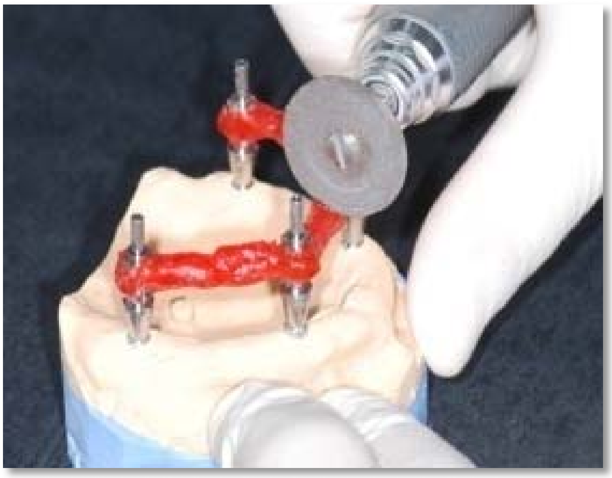


Figure 13. Sectioning the splinted copings

Figure 14. The sectioned splint parts

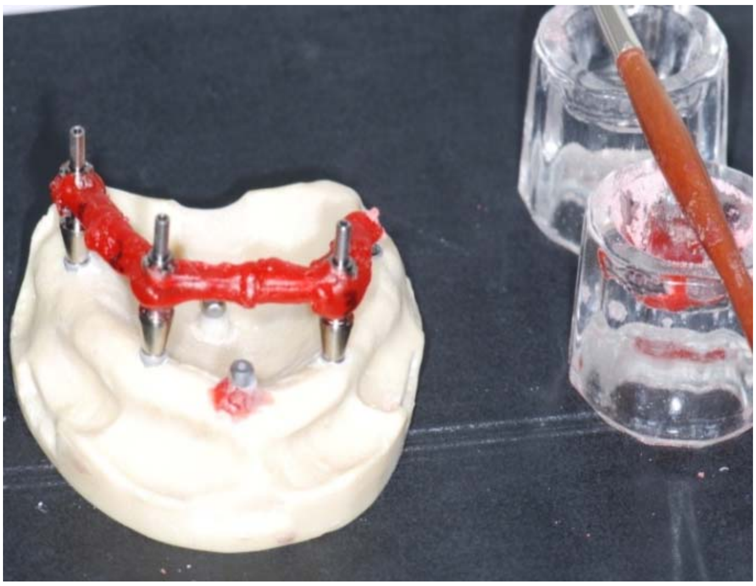


Figure 15. Reconnection of the splint Sectioned parts

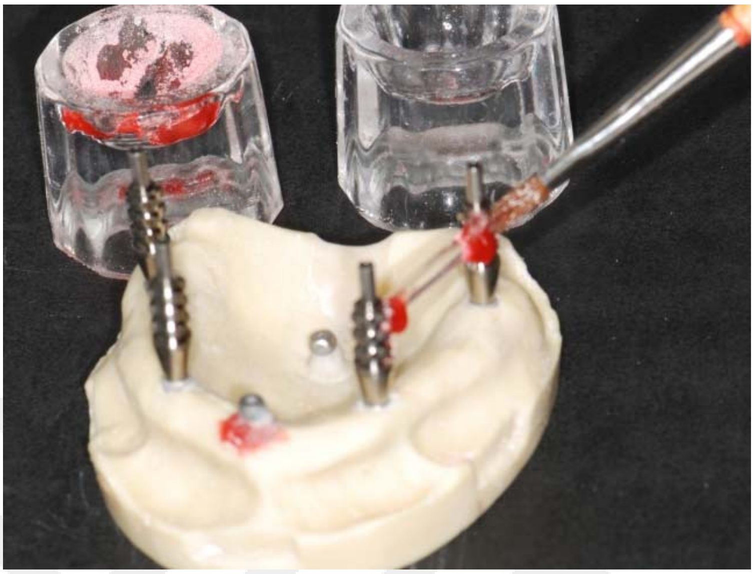


Figure 16. Acrylicbar splinting with GC acrylic using brush

3.6.Impression Material

- Polyvinyl siloxane (Table 1. Line 17) was used for first non-splinted group (N.S PVS) and all the splinted groups
- Polyether impression material (Table 1. Line 19)impression was used for the second non splinted group (N.S PE)
- Alginate impression (Table 1. Line 7)to produce spaced cast for making special trays.

3.7. Pouring the Impressions

Impressions were poured with high strength low expansion die stone (Table 1. Line 9). The die stone was mixed with water according to manufacturer recommendation (16 ml water was used with each 70 gm powder).
The stone was mixed using mechanical vacuum mixer (Table 1. Line 10).

All the impressions were poured on a vibrator (Table 1. Line 11)up to the middle level of implant analogue, after one hour the rest of model was poured.

Casts were separated from the impressions after allowing the stone to set for 2 hours, followed by trimming and labeling to prepare for measurements.

All procedures were completed by the same operator.

3.8. Measurement Protocol

The purpose of our measurement was to measure the distance in (3D dimension and X-Y-Z axes) between each implant, and the posterior reference point in the all 25 model and the control model in order to calculate the absolute discrepancies in each model related to the control model. O-Ring abutments (Table 1. Line 26)were attached to the implants. Throughout the measurements in all the models, the same O-Ring piece was used for the same implant number within the whole measurements in order to avoid machined tolerance mistake. The reason to use an O- Ring abutment that a spherical shape was more helpful for our method.

Starting with the master model, four O-ring abutments (Table 1.26)were hand tightened on the implants clockwise starting with N 17 implant a sand plaster was applied to the O-rings before scanning.

3.8.1. First Step: Casts Digitizing

The master model was placed in a 3D white-light scanner machine (Table 1. Line 27) (Figure 17), with an accuracy of 7µm / 10 µm was used to scan all the 26 models to provide an STL file. The scanning procedure took a duration of 80 sec. for each model. When the scanning was completed, the object support was taken out of the scanner and the master model was removed.

Each O-ring was detached from the implant one by one, then reattached exactly into the same region on the lab analogues of the first stone cast to be scanned, then inserted into the object support and scanned, all the stone casts were scanned with same manner of inserting the O-ring at the same corresponding place to avoid discrepancies produced by O-ring machined tolerance mistake. During the scanning procedure all the models were labeled in a new names in order to hide the model's related group on the next step of the measurement procedure.

3.8.2. Second Step: Defining the Centers

3D computer graphics and computer-aided design application software (Rhinoceros 5.0 Version/ Robert Mc-Neel& Associates, USA) was used to perform the measurements of the distance in 3D Dimension And X-Y-Z Axis. Related STL file was imported to the software, then a procedure of defining the centers of the four O-Rings and the reference points was done as below:

The command (Sphere Command- Fit Points) which able the program to produce a sphere fit to the points of selected object (about 8000 point selected automatically on related object). The head of the O-Ring or the reference point piece were selected and the command was ordered to get a sphere related to that object, then the center of that sphere was defined with a point. This steps were repeated 10 times for each head in order to make the center of the defined centers. This technique has shown a great precision with 1 micron related to the implants centers and 3 microns related to the reference point centers.

The centroid of the posterior reference point was coded as F1

The centroid of the anterior reference point was coded as F2

The centroid of N 27 implant was coded as R1

The centroid of N 23 implant was coded as R2

The centroid of N 13 implant was coded as R3

The centroid of N 17 implant was coded as R4

3.8.3. Third Step: Setting Coordinate Plans

Coordinate plans was set for each model in order to be able to measure the distance in X,Y,Z axes, the posterior reference point (F1) was used to set the all three axis X,Y,Z in zero, anterior reference point was used to set X,Z axis in zero , another reference point produced by the center of the surface connecting the four implants, was used to set X axis in zero. By these steps, all the 26 model had been set in the position on the world plane coordinates.

3.8.4. Fourth Step: Measuring Distances

To measure the distance between the selected mean centers, the (Evaluate pt Command) was used to evaluate the world plane coordinates of the selected center, and displayed in X,Y,Z format which inform the distance from the reference point in X,Y,Z direction. Next (Distance Command) was used to measure the distance in 3D dimension between different centers.

Four measurements was recorded for each implant in (3D, X, Y, Z) distance, and a total of sixteen measurements for each model was recorded. Data was collected and inserted on excel sheet. "Absolute Discrepancies" in each model was calculated by subtraction the recorded value on the model from the related value on the control model. All the values was recorded in absolute numbers. Then statistic analysis was done

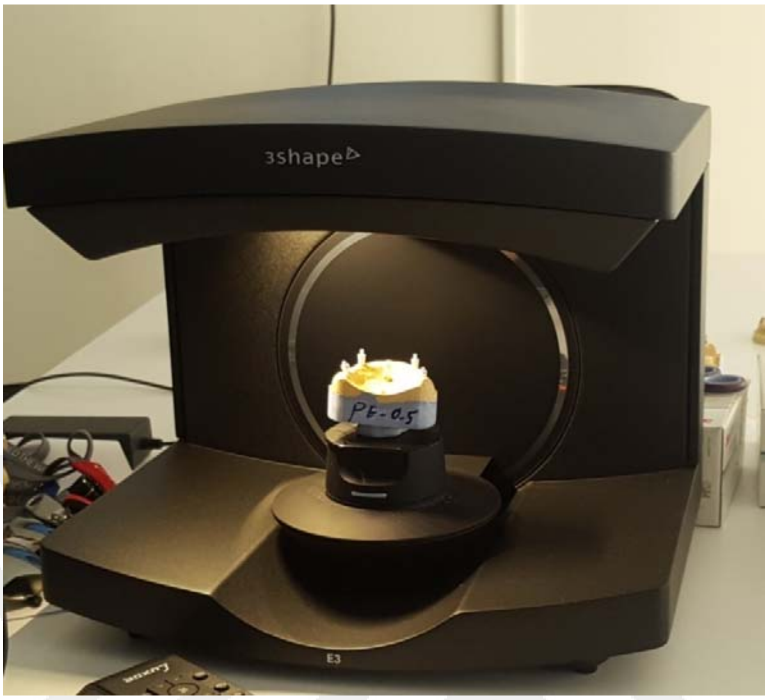


Figure 17.(3 Shape3 E Lab)scanner machine for models digitizing

3.9. Statistical Method :

Standard descriptive statistical calculations were collected for absolute differences in three dimensional (3D) and thee coordinates (X,Y,Z) as (mean, standard deviation). As the normal distribution hypothesis had been rejected after checking the graphic normal distribution plots. Analaysis of variances (ANOVA) according to Kruskal Wallis test was used in the comparison of groups, Mann Whitney-U test was used in the comparison of two groups. Statistical significance level was established at $p < 0{,}05$.

4. RESULTS

4.1. Comparing The Five Groups With Discrepancies Mean Values

The absolute mean value of discrepancies in three dimensional (3D) and three coordinates (X,Y,Z) are presented in (Table 2) (Figures 18-21) for all five groups. Analysis of variances according to Kruskal Wallis test ANNOVA revealed that the (*p* value) was near to be a significant (***p*=0.061**) in relation to (X) coordinate discrepancies. While there was no significant difference between the groups related to three-dimensionaldiscrepancies (3D), Y-axis and Z-axis (*P*=0.166,*P*=0.688, *P*=0.505) respectively.

Table 2. Discrepancies means values in (3D) and three axes X,Y and Z (in µm) for groups

		N.S PVS	N.S PE	S.N.Sec PVS	S.Sec PVS	B.S PVS	*P* value
3D	$\bar{x}\pm$Sd	49±36	42±28	53±46	27±18	44±37	*0.166*
	SE	8	6	0	4	8	
	Median	37	40	37	27	37	
	Min	1	3	4	2	1	
	Max	116	99	170	63	123	
	Range	115	096	166	61	122	
X	$\bar{x}\pm$Sd	26±18	35±31	46±30	27±20	45±37	***0.061***
	SE	4	7	7	4	8	
	Median	18	29	42	25	35	
	Min	1	4	7	2	2	
	Max	59	149	114	065	144	
	Range	58	145	107	63	142	
Y	$\bar{x}\pm$Sd	46±36	48±35	57±49	42±24	42±28	*0.688*
	SE	8	8	11	5	6	
	Median	39	48	48	38	38	
	Min	0.0	3	5	6	4	
	Max	116	134	164	95	102	
	Range	116	131	159	89	98	
Z	$\bar{x}\pm$Sd	56±38	51±40	70±70	55±40	46±24	*0.505*
	SE	9	9	16	9	5	
	Median	57	47	55	48	40	
	Min	4	3	8	0.0	6	
	Max	135	163	306	127	90	
	Range	131	160	298	127	084	
	n	5	5	5	5	5	

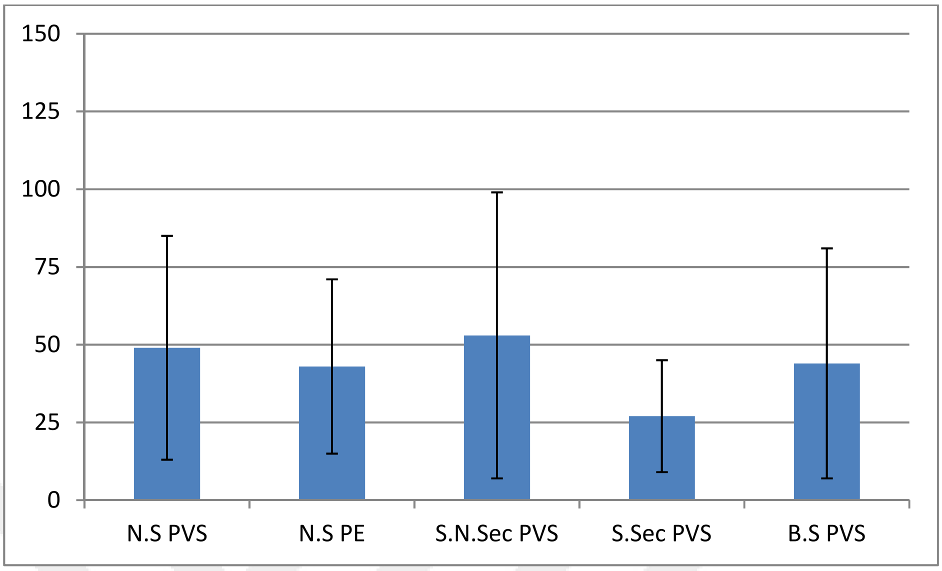


Figure 18. Means of the absolute discrepancies values in 3D for all groups (in µm)

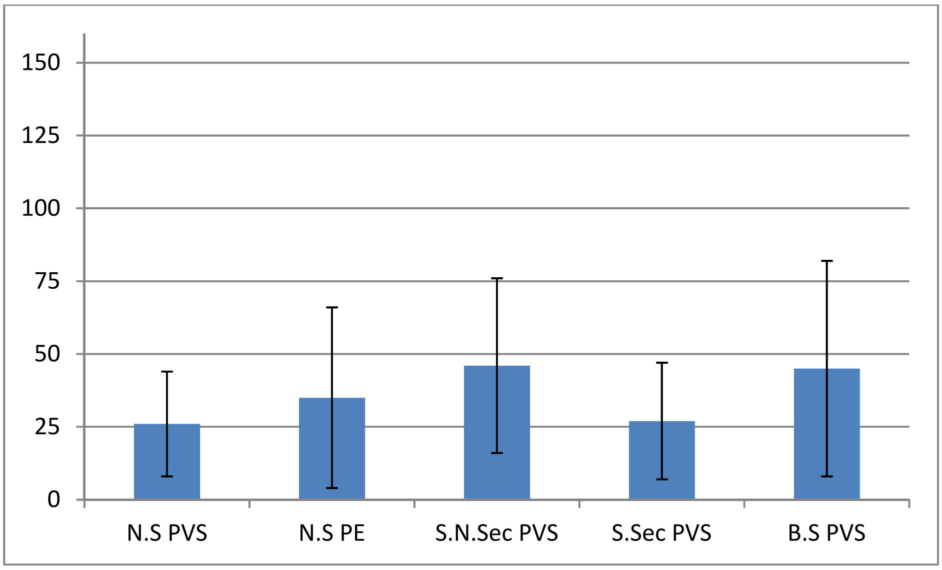


Figure 19. Means of the absolute discrepancies values in X coordinate for all groups (in µm)

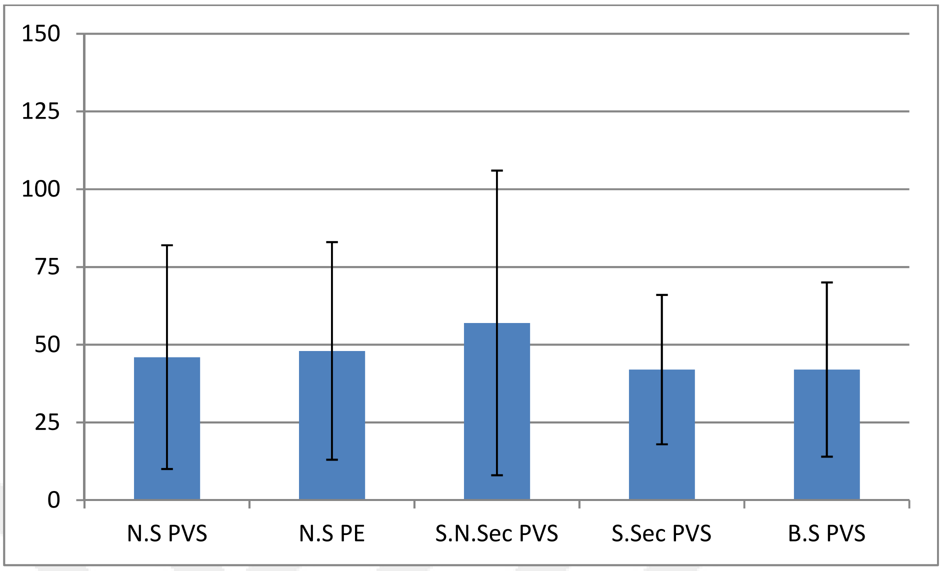


Figure 20. Means of the absolute discrepancies values in Y coordinate for all groups in (in µm)

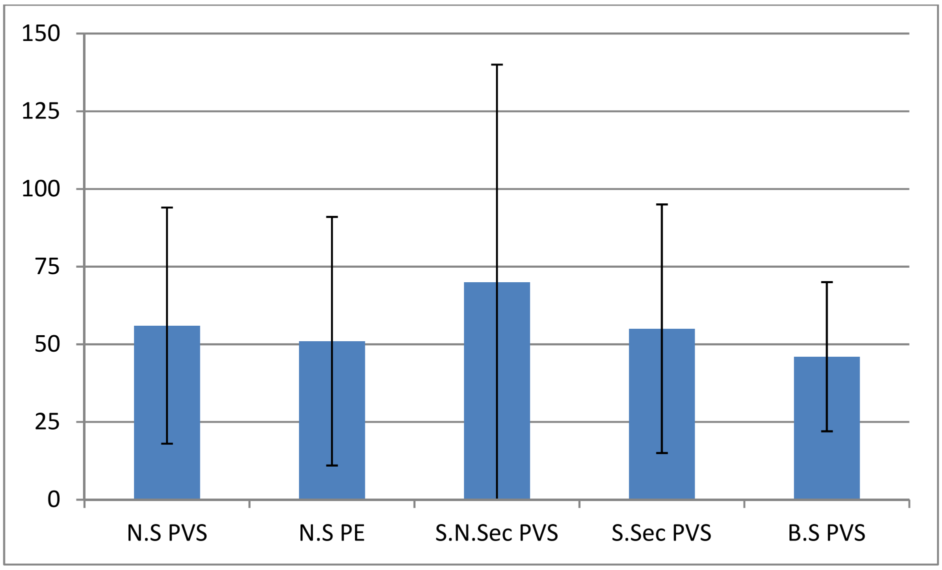


Figure 21. Means of the absolute discrepancies values in Z coordinate for all groups (in µm)

4.2. Comparing Different Types of Impression Techniques

The absolute mean value of discrepancies in three dimensional (3D) and three coordinates (X,Y,Z) for all groups are presented as mean and standard deviation. Mann Whitney U Test was made for each twogroups(Table 3), and the following results were collected :

Table 3. Comparison of each two groups together

	3D	X	Y	Z
N.S PVS * N.S PE	*P=0.841*	*P=0.369*	*P=0.779*	*P=0.478*
N.S PVS * S.N.Sec PVS	*P=0.925*	***P=0.014***	*P=0.718*	*P=0.799*
N.S PVS * S.Sec PVS	*P=0.068*	*P=0.904*	*P=0.947*	*P=0.968*
N.S PVS * B.S PVS	*P=0.620*	*P=0.091*	*P=1.000*	*P=0.383*
N.S PE * S.N.Sec PVS	*P=0.718*	*P=0.157*	*P=0.758*	*P=0.429*
N.S PE * S.Sec PVS	*P=0.063*	*P=0.495*	*P=0.678*	*P=0.883*
N.S PE * B.S PVS	*P=0.758*	*P=0.565*	*P=0.547*	*P=0.758*
S.N.Sec PVS * S.Sec PVS	*P=0.086*	***P=0.030***	*P=0.602*	*P=0.698*
S.N.Sec PVS * B.S PVS	*P=0.602*	*P=0.659*	*P=0.640*	*P=0.429*
S.Sec PVS * B.S PVS	*P=0.231*	*P=0.142*	*P=0.947*	*P=0.862*

Mann-Whitney U-test.

4.2.1.ComparingNon-Splinted PVS and Non Splinted PE (N.S PVS*N.S PE)

The results of our study in (3D) discrepancies showed a higher discrepancy with N.S PVS ($\bar{x}$=49±36). The N.S PE group showed 7μm less mean discrepancy ($\bar{x}$=42±28).

For (X) axis, a higher discrepancy found with N.S PE ($\bar{x}$=35±31). The N.S PVS group showed a ($\bar{x}$=26±18). Also in (Y) axis higher discrepancy found with N.S PE ($\bar{x}$=48±35), but the N.S PVS group showed ($\bar{x}$=46±36).

While the higher discrepancy in (Z) axis found with N.S PVS($\bar{x}$=56±38), and for N.S PE group showed ($\bar{x}$=51±40) (Table 2) (Figures 18-21).

Statistical analysis with Mann Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (p=0.841, p=0.368, p=0.779, p=0.478) (Table 3).

4.2.2. Non Splinted PVS vs Splinted Non Sectioned PVS Comparison (N.S PVS*S.N.Sec PVS)

Analysis revealed that there was a significant difference between groups related to (X) coordinate discrepancies (***p=0.014***) with the higher discrepancy found with S.N.Sec PVS group ($\bar{x}$=46±30). The N.S PVS group showed ($\bar{x}$=26±18).

For three dimensional (3D) discrepancies a higher mean discrepancy found with S.N.Sec PVS group($\bar{x}$=53±46),while the N.S PVS group showed ($\bar{x}$=49±36).

A higher discrepancy found with S.N.Sec PVS group in relation to (Y)coordinate discrepancies($\bar{x}$=57±49). The N.S PVS group showed ($\bar{x}$=46±36).

In (Z) coordinate discrepancies a higher discrepancy found with S.N.Sec PVS group ($\bar{x}$=70±70) which is the highest discrepancy and Sd± among the all measures. The N.S PVS group showed ($\bar{x}$=56±38) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and the other two axes (3D,Y,Z) (p=0.925, p=0.718, p=0.799) (Table 3).

4.2.3. Non Splinted PVS vs Splinted Sectioned PVS Comparison (N.S PVS * S.Sec PVS)

According to our results in three dimensional (3D) discrepancies, a higher discrepancy found with N.S PVS group ($\bar{x}$=49±36),while the S.Sec PVS group showed a noticeable results ($\bar{x}$=27±18), with 22 µm less.

For the measurements related to (X)coordinate discrepancies, a higher discrepancy found with S.Sec PVS group($\bar{x}$=27±20). The N.S PVS group showed ($\bar{x}$=26±18).

But in (Y) coordinate, a higher discrepancy found with N.S PVS group ($\bar{x}$=46±36). The S.Sec PVS group showed ($\bar{x}$=42±24). Also in (Z)coordinate discrepancies a higher discrepancy found with N.S PVS group($\bar{x}$=56±38). The S.Sec PVS group showed ($\bar{x}$=55±40), which are not comparable results (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (p=0.068, p=0.904, p=0.947, p=0.968) (Table 3).

4.2.4. Non Splinted PVS vs Bar Splinted PVS Comparison (N.S PVS * B.S PVS)

By comparing the results in three dimensional (3D) changes, a higher discrepancy found with N.S PVS group($\bar{x}$=49±36), while the B.S PVS group showed ($\bar{x}$=44±37).

For the (X) coordinate, a higher discrepancy found with B.S PVS group($\bar{x}$=45±37) while the N.S PVS group showed 19 µm less with ($\bar{x}$=26±18).

But in (Y) coordinate, a higher discrepancy found with N.S PVS group ($\bar{x}$=46±36). The B.S PVS group showed ($\bar{x}$=42±28).Also in (Z)coordinate the higher discrepancy found with N.S PVS group ($\bar{x}$=56±38). The B.S PVS group ($\bar{x}$=46±24) (Table 2) (Figures 18-21).

Statistical analysis revealed that there was no significant difference between groups in three dimensional (3D) and three axis (3D,X,Y,Z) discrepancies (*p*=0.620, *p*=0.091, *p*=1.000, *p*=0.383) (Table 3).

4.2.5. Non Splinted PE vs Splinted Non Sectioned PVS Comparison (N.S PE * S.N.Sec PVS)

The results of our study in (3D) discrepancies showed a higher discrepancy with S.N.Sec PVS ($\bar{x}$=53±46). The N.S PE group showed 11µm less mean discrepancy($\bar{x}$=42±28).

For (X) axis, a higher discrepancy found with S.N.Sec PVS ($\bar{x}$=46±30). The N.S PE group showed a ($\bar{x}$=35±31). Also in (Y) axis higher discrepancy found with S.N.Sec PVS ($\bar{x}$=57±49), but the N.S PE group showed ($\bar{x}$=48±35).

Even in (Z) axis a higher discrepancy found with N.Sec PVS ($\bar{x}$=70±70), while for N.S PE group showed ($\bar{x}$=51±40) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (*p*=0.718, *p*=0.157, *p*=0.758, *p*=0.429) (Table 3).

4.2.6. Non Splinted PE vs Splinted Sectioned PVS Comparison (N.S PE * S.Sec PVS)

According to results in three dimensional (3D) changes, a higher discrepancy found with N.S PE group($\bar{x}$=42±28), while the S.Sec PVS group showed 15µm less mean discrepancy($\bar{x}$=27±18).Even in (X)coordinate discrepancies, a higher discrepancy found with N.S PE group with ($\bar{x}$=35±31), and for the S.Sec PVS group showed ($\bar{x}$=27±20).

Also in relation to discrepancies in (Y)coordinate, the higher discrepancy found with N.S PE group with ($\bar{x}$=48±35). The S.Sec PVS group showed ($\bar{x}$=42±24).

For the (Z)coordinate discrepancies, the higher discrepancy found with S.N.Sec PVS group with ($\bar{x}$=55±40). The N.S PE group showed ($\bar{x}$=51±40) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (p=0.063, p=0.495, p=0.678, p=0.883) (Table 3).

4.2.7. Non Splinted PE vs Bar Splinted PVS Comparison (N.S PE * B.S PVS)

According to results in three dimensional (3D) changes, a higher discrepancy found with B.S PVS group ($\bar{x}$=44±37). The N.S PE group showed ($\bar{x}$=42±28).

For (X) coordinate, a higher discrepancy found with B.S PVS group ($\bar{x}$=45±37). The N.S PE group showed 10μm less mean discrepancy ($\bar{x}$=35±31).

For (Y)coordinate, a higher discrepancy found with N.S PE group ($\bar{x}$=48±35). The B.S PVS group showed ($\bar{x}$=42±28). Also for (Z) coordinate the higher discrepancy found withN.S PE group($\bar{x}$=51±40). The B.S PVS group ($\bar{x}$=46±24) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (p=0.758, p=0.565, p=0.547, p=0.758) (Table 3).

4.2.8. Splinted Non Sectioned vs Splinted Sectioned PVS Comparison (S.N.Sec PVS * S.Sec PVS)

According to results in three dimensional (3D) changes, a higher discrepancy found with S.N.Sec PVS group ($\bar{x}$=53±46). The S.Sec PVS group showed 26 μm less mean discrepancy ($\bar{x}$=27±18).

There was a significant difference between groups related to(X) coordinate discrepancies (***p=0.030***) (Table 3), with the higher discrepancy found with S.N.Sec PVS group ($\bar{x}$=46±30). The S.Sec PVS group showed 19 μm less mean discrepancy ($\bar{x}$=27±20).

For (Y) coordinate, the higher discrepancy found with S.N.Sec PVS group($\bar{x}$=57±49), while the S.Sec PVS group showed 17 μm less mean discrepancy ($\bar{x}$=42±24). Also for (Z) coordinate, a higher discrepancy found with S.N.Sec PVS group with (x̅=70±70), while the S.Sec PVS group showed 15 µm less discrepancy (x̅=55±40) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and the other two axes (3D,Y,Z) (*p*=0.086, *p*=0.602, *p*=0.698) (Table 3).

4.2.9. Splinted Non Sectioned vs Bar Splinted Comparison PVS (S.N.SEC PVS*B.S PVS)

According to results in three dimensional (3D) changes, a higher discrepancy found with S.N.Sec PVS group(x̅=53±46). The B.S PVS group showed (x̅=44±37).

For (X) coordinate, a higher discrepancy found with S.N.Sec PVS group(x̅=46±30). The B.S PVS group showed (x̅=45±37). Also in (Y) coordinate discrepancies, a higher discrepancy found with S.N.Sec PVS group(x̅=57±49). The B.S PVS group showed (x̅=42±28).

Even in (Z) coordinate, the higher discrepancy found with S.N.Sec PVS group with (x̅=70±70), while the B.S PVS group showed 24 µm less mean discrepancy (x̅=46±24) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (*p*=0.602, *p*=0.659, *p*=0.640, *p*=0.429) (Table 3).

4.2.10. Splinted Sectioned vs Bar Splinted Comparison (S.Sec PVS*B.S PVS)

The results of our study in (3D), showed a higher discrepancy with B.S PVS group with (x̅=44±37). The S.Sec PVS group showed 17 µm less mean discrepancy (x̅=27±18).

Also for (X)coordinate, a higher discrepancy found with B.S PVS group (x̅=45±37). The S.Sec PVS group showed 18µm less mean discrepancy (x̅=27±20).

For the (Y) coordinate, the discrepancy related to S.Sec PVS and B.S PVS groups were almost the same with (x̅=42±24) and (x̅=42±28) respectively.

For the (Z) coordinate, a higher discrepancy found with S.Sec PVS group ($\bar{x}$=55±40), while the B.S PVS group showed ($\bar{x}$=46±24) (Table 2) (Figures 18-21).

Statistical analysis with Mann-Whitney U-test revealed that there was no significant difference between groups in three dimensional and three axis (3D,X,Y,Z) (p=0.231, p=0.142, p=0.947, p=0.862) (Table 3).

5. DISCUSSION

Accuracy of impression directly affects the clinical fit of implant prosthesis as many researchers investigated the fit of the prosthesis framework on the produced cast. Many methods of assessment were used such as strain gauges and compared this fit on the reference master cast (33,36).While the accepted level of discrepancies stated by Branemark and ma to be between 10-100 µm. Assuncato et al (32) stated that even a 50 µm discrepancy in any axis could produce a good impression. Papaspyridakos et al in his conclusion stated that the maximum range of discrepancy or misfit that will not lead to a clinical complications is 72 µm in one-piece implant-supported prosthesis. Other studies have evaluated the accuracy indirectly by measuring inter-implant distances on the working casts and compared the resultant measures to a control cast (8,27,32,34,44,47).

Computerized coordinate measuring machine, optical microscope, laser video-graphy are some of the techniques that have been used in the assessment of inter-implant 3-D deviations (8,28) and recently optical scanning and cast digitizing has being used and said to be the most accurate method to be used (19).However with the advent of 3-D measurement devices, a 2-D assessment of the accuracy cannot be accepted today for scientific purposes. Optical scanning and dedicated software for superimposition of the scanning data sets is currently an efficient and precise technique to measure and compare the 3-D discrepancies at the microscopic level between different groups and thus seems to be the recommended technique for future investigations (38).

5.1. Discussion Of Methodology

The aim of this study is to evaluate two main factors that believed to affect the impression accuracy that would lead to clinical misfit of implant supported fixed prosthesis, these factors are (impression material and coping splinting technique), through comparing the inter-implant distances of the resultant casts gained by different implant impression techniques with the master cast.

The study has compared the discrepancies in (X,Y and Z axes) and 3D changes of five groups in relation to the master cast, two non-splinted groups with different impression material (PVS & PE) to find out if there is a significant different between both materials which are the most widely used material and had been advised by many authors . The other three groups obtained by different impression coping splinting techniques using PVS impression material were compared with both non-splinted group (N.S PVS&N.S PE), and also were compared with each other to find out if there is a comparable result between splinted and non-splinted groups and which kind of splinting technique would give an advantage to the accuracy of casts, all the impressions were made by direct “open tray” technique.

For the measurements, an optical scanner (3D Shape 3E Lab Scanner) with dedicated software was used in the digitizing of all casts obtained from all the groups and the master cast was also digitized for a precise measurement. The analysis of the measurements of all casts was performed using industrial software (Rhinoceros 5.0 version USA).

The methodology of our study was standardized in order to avoid the effect of the other variable. That include the use of a new coping for each impression in order to avoid the error which might produced from reuse of the copings. All the impression were done using a new custom tray with 3 mm space in order to provide enough and uniform thickness of the impression material , where some author reported an effect of the impression material thickness on the end outcome, the custom tray where used just one time. To decrease effect of the dimensional changes of impression material the manufacture instruction was followed and all the impressions were poured within 24 hour and not before 1 hour in order to get the best results. In order to decrease the error out of pouring procedure two step pour technique were used, that the impression is poured with auto-mix machine up to the half of the implant analogs, and after the set of the first pour around 1 hour, the second pour were performed. It has been reported that this technique decrease the stone expansion (57). In addition type four stone were used which considered to be the best stone material in term of less dimensional changes. Single operator did the whole steps to prepare the models to decrease the intra-operator errors.

While making the scan for the prepared models, an O-ring abutment where attached over each implant analogue, and in order to avoid the scanning powder which reported to form around 12micron layer thickness, sandblasting where performed to each abutment to make it scannable for the scanning machine. In addition the same abutment (O-ring) where used for the same implant number in order to avoid the difference within those abutment and avoid the machining tolerance which believe to be around 50 micron. Other author reported that implant component discrepancies ranging from 22 to 100 micron (71).

One of the advantage of our study, the use of an anatomical model with edentulous upper jawwhich simulate the clinical situation in term of undercut and spaces between implants. It simulate the strain generated during impression removal from patient mouth instead of using a smooth and flat blocks. Another advantage for our study that a very precise method were used for assessing the dimensional changes. Scanning machine which were used has a systemic error of 7 to 10 µm, while the measuring procedure on the three dimensional designing program had an error of 3 µm, which has been considered accurate enough for our measurement.

The other factors that were believed to affect the accuracy of impression taking such as implant angulations, impression technique (open or close) were eliminated as we used a parallel implants perpendicular on the horizontal plane, also all the impressions were taken using direct “open tray” technique and the same impression material (PVS) was used for all splinted groups.

In this study, the absolute mean value of discrepancies in 3D and coordinates between the experimental casts and master cast ranged between (27 to 53µm) for 3D, (26 to 70µm) for coordinates, which falls within the range (0.6 to 136µm) reported by most of the studies that evaluated the accuracy of casts gained by different impression technique. Even this leads to the fact that it is still impossible to achieve a full mouth fixed prosthesis with completely passive fit to the abutments. It could be as a result of tolerance among components of the implant system, impression transfer procedures, investing, casting and alloy properties, and the impression materials expansion.

To accommodate for impression inaccuracy, sectioning and soldering has been suggested to overcome such problems arises from prosthesis misfit, but an extra time and cost will be added (70).

The CAD/CAM technology has been introduced and improved the framework fabrication accuracy and increased the precision of fit for one-piece bridges (37).

In practice a lot of clinicians prefer to use abutment level implants, however it is believed that there would be limitation in vertical spaces especially with angulated placement. For that reasons, implant level impression technique will show a great advantage (72).

Many materialshave been used as splinting material like light-curing composite resin, impression plaster, orthodontic wire,acrylic resin and auto polymerizing acrylic resin (39,44). The most commonly used material as splint is auto polymerizing acrylic resin, the dimensional shrinkage of resin is one of the main drawback points, which need to be considered. Mojon et al. investigated the shrinkage behavior of acrylicresin, and he reported that the total shrinkage about 6.5% - 7.9% and around 80% of the total shrinkage occurs within the first 17 min(53). Some authors had stated that such shrinkage might lead to distortion of the impression coping position within the impression material (46). In order to avoid this disadvantage, a prefabricated transparen tacrylic bars were advised to be used in which pieces 0.5mm shorter than the distance between two implants could be used, then connect them to the impression copings using duralayacrylic which provide an easy and fast method to make the splint and more applicable to the clinic (73).Some authors had stated that sectioning then reconnecting of the splinted acrylic resin minimizes the effect of shrinkage to a neglected amount (51).

5.2. Discussion Of Results

As a result of this study, the first hypothesis was accepted as the casts obtained from PVS and PE non splinted groups showed no significant different in accuracy in term of 3D changes (p=0.841) and (X,Y,Z) coordinates (p=0.368, p=0,779, p=0,478) when compared to the master cast, this result was similar to some other studies. liou et al. 1993, wenz et al. 2008, akalin et al 2013, Mostafa et al 2010, Aguilar et al 2010, Papaspyridakos et al 2014).
Lee et al authored that PVS impression material has a superior result on PE .
Del'acqua et al 2010 suggested that PE impression material is better than PVS.

When the PVS non-splinted group were compared with splinted group, the results showed that there was no significant difference between non-splinted PVS group and two of the splinted groups which are splinted-sectioned using duralayacrylic group for (3D, X, Y, Z) (p=0.068, p=0.904, p=0.947, p=0.968), and between non-splinted PVS group and acrylic bar splinted group for (3D, X, Y, Z) (p=0.620, p=0.091, p=1.000,p=0.383), but there was a significant different between non splinted PVS group and splinted non-sectioned using duralayacrylic group related to (X) coordinate (p=0.014) as the non splinted PVS showed ($\bar{x}$=26±18) while the splinted non-sectioned group showed ($\bar{x}$=46±30), So the second hypothesis that there would be no significant difference between the splinted groups and the non splinted groups were rejected. which leads to the fact that there is no need for splinting of copings when we have a parallel implants with the use of open technique, also the use of duralayacrylic for splinting of copings without sectioning gives more deviation and shouldn't be used if we decided to use splint in cases of angulated implants as advised by some authors that splinting has an advantage on accuracy if the implants were put in an inclined position

The results of this study were in convenience with other studies, Spector et al. measured the accuracy of three impression procedures using pick-up and transfer impression copings and a parallel six-implant model, he divided the groups to splinted and non splinted groups. The results showed that no technique proved to be more accurate. However the shrinkage of the acrylic resin would create some error during the pick-up procedure (41).

Humphries et al. investigated the dimensional accuracy of master casts fabricated using tapered copings group and squared copings group notsplinted together and the third squared group has been splinted with acrylic resin without sectioning of the acrylic. A parallel four implant model was used. All impressions were made in custom trays with a two-stage addition-reaction silicone material. Results showed that the non-splinted tapered coping technique, gave more accurate results than the non splinted and splinted squared polymer coping techniques(46).

Hsu et al. compared the accuracy of polyether impressions made by four techniques: non-splinted square copings, dental floss and duralay resin splinted copings, stainless steel orthodontic wire and duralay splinted copings and copings splinted using prefabricated blocks of duralay. The study concluded that the bulk volume of duralayacrylic resin used for splinting is an insignificant factor in impression transfer accuracy, there was no significant difference between the splinted and non-splinted copings (44).

Phillips et al. compared the accuracy of three implant impression techniques using tapered copings, square copings alone and square copings with acrylic resin splint. The implant replicas had a 10 degree angulations toward the labial. The authors found out that there was no significant difference between the splinted vs. non-splinted technique accuracy as well as between square and tapered copings. However, authors consider the splinting technique to be lengthy, complicated and not more accurate than the non-splint technique and therefore unnecessary (59).

Burawi et al. used five implants in his study to compare the dimensional accuracy of a splinted impression copings and compared it with another non-splinted group. The splinted technique showed more deformation than the un-splinted technique as he used autopolymerizing acrylic resin not sectioned for the splinted group, and stated that shrinkage of acrylic would cause deviation in copings and shouldn’t be used (42).

Herbst et al. investigated implant impressions which were made using four techniques: in the first group a tapered impression copings not splinted was used, for the second group a squared impression copings not splinted, the third group used splinted squared impression copings by duralayacrylic resin, and for the fourth group a modified squared impression copings as it has a lateral extension on one side without the use of splint. The impression material used in all groups was additional silicone. The open trays technique were used for the squared copings besides closed trays for the tapered copings, there weren't any angulations between implants as a complete parallelism was performed. The end results of this research was that there was no significant difference could be detected between splinted and non-splinted groups (27).

Choi et al. used two implant level implants in his evaluation of accuracy and divided their groups as: one pick-up non-splinted (square impression copings) and one splinted (square impression copings splinted with duralayacrylic resin), and used custom trays in impression taking for all the samples. The implants were put as one perpendicular and the other one was 8 degree divergent from the first implant using a laboratory model. The non-splinted and splinted techniques didn't show any variations on cast accuracy and splinting doesn't seems to have an advantage effect on accuracy with divergence up to 8 degrees (33). Some other studies preferred the use of splinting for the copings especially with angulated implants such as:

Assif et al. assessed the accuracy of three impression techniques: non-splinted square copings, copings splinted with autopolymerizing acrylic resin and copings splinted directly to an acrylic resin custom tray. The authors used five parallel implant analogs in a mandibular master cast. The technique using acrylic resin to splint the transfer copings was significantly more accurate than the two other techniques (45).

Vigolo et al. used polyether impression material in comparing the accuracy of three different impression techniques. In the first group non-modified square impression copings were used, in the second a square impression copings were used and joined together with duralayacrylic resin just before the impression procedure, and in the third a square impression copings, previously airborne particle abraded and coated with the manufacturer-recommended impression adhesive, were used. The best results and more accurate cast replication could be gained by the square impression copings joined together with duralayacrylic resin also the square impression copings group which air abraded and adhesive where applied on it (48).

Vigolo et al. used polyether impression material in comparing the accuracy of three different impression techniques when the implant would be placed deep sub-gingivally. The authors used a connection system that had a 4-mm–deep internal lock with thick walls. Results: The splinting of coping in this situation has an advantage effect on the accuracy of casts produced on other non-splinted, air–abraded, adhesive-coated impression copings groups that had been tested in study (49).

Assuncao et al. investigated the effect of various implant angulations on the implant impressions accuracy under different parameters: transfer technique with conical copings, pick-up technique with square copings and square copings splinted with duralayacrylic resin. They investigated also four types of impression materials: polysulfide, polyether, addition silicone and condensation silicone. Results: The splinted technique showed better accuracy (32).

Assuncao et al. compared three different impression techniques for two external connection implants with two different inclinations: First implant perpendicular to the occlusal surface and the other with 25 degrees divergence to first implant. Polyether impression materials were used for the three impression techniques: square impression copings splinted with acrylic resin, square copings splinted with prefabricated autopolymerizing acrylic bar and non-splinted square copings applied to air-abrassion. Results showed that the non splinted group produced casts that were less accurate than the splinted groups (34).

Cabral & Gudes investigated the following four techniques: a transfer impression technique with tapered transfer copings, a pick-up impression technique with un-splinted squared copings, a pick-up impression technique with square copings splinted with duralayacrylic resin, and a pick-up impression technique with square transfer copings with duralayacrylic resin splints sectioned after complete setting of the material and then reconnected with same resin material to overcome the shrinkage effect of resin material resin. The best results regarding cast accuracy could be gained by the group where the copings had been splinted then sectioned and reconnected by the same resin material (51).

Filho et al tested the effect of different coping splinting techniques upon impression accuracy, in this study the implants where put in different angulations, and an open/pick up technique was used in all groups with use of PVS impression material (35).

6. CONCLUSION.

The following conclusion were drawn out of this study:

1. Slightly less (3D) discrepancies where recorded for polyether impression material ($\bar{x}$=42±28) while ($\bar{x}$=49±36) for polyvinyl siloxane impression material. Although we could accept both material for implant impression procedure.

2. Splinted Non-Sectioned Auto-polymerizing Acrylic Resin Splint Group recorded the highest discrepancy among the all groups with ($\bar{x}$=53±46) in 3D, ($\bar{x}$=46±30)in x-axis, ($\bar{x}$=57±49) in y-axis, and ($\bar{x}$=70±70) in z-axis.

3. Splinted Sectioned Auto-polymerizing Acrylic Resin Splint Group recorded the minimum discrepancy among the all groups with ($\bar{x}$=27±18) in 3D, ($\bar{x}$=27±20)in x-axis, ($\bar{x}$=42±24) in y-axis, and($\bar{x}$=55±40) in z-axis.

4. Result of this study while the implants where positioned in parallel way,splinting of impression coping did notshow a clear effect on impression accuracy.However a better result could be reached with Splinted Sectioned Auto-polymerizing Acrylic Resin Splint Group.

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