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A Comparison Of Passive Fit Between Conventional And Digital Impression Techniques For An All-On-6 Maxillary Framework: An Invitro Study

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Abstract: *The main objective of the current in-vitro study is to compare the passive fit of an implant supported framework fabricated using conventional open tray impression versus the digital impression for 6 parallel implants restoring edentulous maxilla.*

Materials and Methods*: Six implants will be installed in the epoxy edentulous cast using trial denture base set up of teeth. All implants will be installed using dental surveyor to ensure parallelism of all 6 implants, installed in central, canine, and second premolar areas bilaterally.*

In this invitro study two frameworks will be fabricated; in group 1 a casted conventional framework using a conventional open tray impression, while in group 2 a milled framework will be fabricated using a digital impression, and in each group 5 frameworks will be fabricated.

In Group 1: Five Splinted open tray conventional Impressions will be carried out for all of the six installed implants; each impression will be poured in a conventional manner to obtain a master cast. This master cast will be used for fabrication of a casted superstructure framework.

Group 2: Scan bodies will be screwed to all the installed implants, and five digital impressions using an intra-oral scanner will be carried out. The STL files of the five impressions will be used to fabricate 5 milled superstructure frameworks using exocad software.

Passive fit of all frameworks fabricate in the two groups will be evaluated in the present invitro study using two methods; the first method is the Sheffield test and that would be assessed as passive or non-passive, and the second method will be measuring the gap distance between the framework margin and the implant interface at each implant using stereomicroscope to evaluate the passive fit of the frameworks.

Results*: Evaluating the passive fit of implant supported full arch maxillary framework fabricated using conventional and digital technique, there was a statistically significant higher vertical gap distance for digitally fabricated milled frameworks compared to the conventional casted framework.*

Conclusion: *Absolute passive fit can't be achieved regardless of the type of material and technique used. Further evaluation of the reliability and accuracy of the digital impression approach for implant full arch cases must be undertaken in both laboratory and clinical settings.*

KeyWord*: Implant, Full Arch, Edentulous Maxilla, Passive fit, Casted Framework, Milled Framework, Digital Impression, Conventional Impression.*

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I. Introduction

Rehabilitation of edentulous maxilla has been more challenging when compared to the mandible due to vertical and horizontal alveolar bone resorption and compromised bone quality, especially in the posterior region of the maxillary arch, where bone grafting is often indicated due to maxillary sinus pneumatization. (1)

Although All on four concept for edentulous mandible achieves high success rate, Browaeys et al showed significantly lower implant success after 1 year in maxilla (56%) compared with the mandible (90%) when implants were immediately loaded with an All-on-4 full-arch screw-retained prosthetic bridge. Moreover, the oral hygiene of the hybrid All on four fixed restoration is challenging due to presence of extensive prosthetic flanges which induce more plaque accumulation. (2)

As an alternative to the conventional All on four implant concept, Agliardi and colleagues reported that six implants could be considered a predictable and cost- and time-effective option for the immediate restoration of the edentulous maxilla, avoiding bone grafting procedures. (3)

In implant supported prostheses, reduced stress along the implant and surrounding bone is a desired feature. This could be possible through a passive fit of the prosthesis' superstructure on the implant abutments. (4)

Several definitions of passive fit primarily describe it as an implant-supported restoration that produces no strains on prosthetic, implant or surrounding structures, when the prosthesis-implant interface is maximally congruent. (5)

The passive fit of implant supported prostheses to the underlying structures is fundamental for successful and survival of the osseointegrated prosthesis. (6,7)

Any misfit of the framework to the osseointegrated implants, clinically detectable or not, is believed to induce internal stresses in the prosthesis' framework, the implants, and the bone surrounding the implant. (8)

The conventional workflow for implant prosthetic rehabilitations have been chosen in clinical practice for a long time as the leading technique, although it is a procedure that requires several manual manufacturing steps, as well as skilled dental technicians and impression materials, are prone to undergo dimensional variations. (9)

The accuracy of the impression, is considered the main factor influencing the structures' fit, is affected by impression material, impression technique, implant angulation, the number of implants. An optimal fit of the implant-fixed prosthesis is required for its long-term success. (10)

Any incorrect framework may lead to mechanical complications as screw loosening or fracture (10)) and biological complications, which could compromise the bone–implant interface and also the homogenicity of the occlusal load. (11)

An accurate implant impression is an integral prerequisite for obtaining an accurate master cast which is the key for the fabricating an accurately fitting prosthesis. (12)

A systematic review on the accuracy of implant impression techniques reported that splinting of the impression copings prior to impression-making produces a more accurate definitive cast than non-splinting for both partially and completely edentulous patients. (13)

Moreover, it has been stated that there is no difference in accuracy between open-tray and closed-tray impressions for partially edentulous patients; however, open-tray impressions were found to be more accurate than closed-tray impressions for patients with complete edentulism. (13)

Even though no technique has yet been identified as the gold standard, intraoral digital impressions can be considered a reliable alternative for fixed implant prosthetic restorations. (14,15,16)

The elaboration of a digital approach has been proven to be even more accurate (17) and efficient (18) than conventional materials.

Intraoral scanners (IOS) are devices for capturing direct optical impressions in dentistry. (19.20,21) Similar to other three-dimensional (3D) scanners, they project a light source (laser, or more recently, structured light) onto the object to be scanned, in this case the dental arches, including implant scanbodies (i.e. cylinders screwed on the implants, used for transferring the 3D implant position). (20,21) The images of the implant scanbodies captured by imaging sensors are processed by the scanning software, which generates point clouds. These point clouds are then triangulated by the same software, creating a 3D surface model (mesh). (21,22)

The 3D surface models of the dental arch are the result of the optical impression and are the 'virtual' alternative to traditional plaster models. (22,23)

Since the digital impressions are instantly sent and saved/stocked electronically for the fabrication of definitive prosthetic restorations, (24) thus enhancing efficiency of the workflow, the IOS has proved the decrease of margin of error caused by traditional impression taking (25) and cast production methods. (26). Several published studies have examined digital impression techniques in implant dentistry. (16)

Papaspyridakos et al. concluded in a comparative study that the use of intraoral scanners for full-arch implant rehabilitations is significantly more accurate than conventional impressions.(27)

An in vitro study of 2019 comparing impression techniques for dental implants concluded that in a clinical situation with less than 3 implants conventional impression is more accurate, while in cases of 4 implants the IOS has a superior accuracy. (28)

Furthermore, from a systematic review evaluating the advantages of digital technologies for the manufacturing of implant-supported rehabilitations, it emerged the increased efficiency of CAD/CAM systems compared to conventional fabrication procedures. (29)

While absolutely passive fit of the restoration is virtually impossible, various measures have been introduced to enhance the fit of the prosthesis. Clinical and laboratory methods of passivity assessment have been published in the literature, but they all have their limitations. (30,31,32)

II. Material And Methods

PICO

- **P**opulation: completely edentulous maxilla
- **I**nterventions: digital impression technique
- **C**omparator: conventional open tray impression technique
- **O**utcome: passive fit of superstructure **using one screw test and stereomicroscope.**

Prioritization of Outcome	Outcome	Method of Measurement	Unit of Measurement
Primary outcome	Passive fit of superstructure	Sheffield test (one screw test) And measuring vertical gap distance.	Binary Micrometers, Using stereomicroscope.

Study design:

- In vitro study
- Parallel group study
- Allocation ratio 1:1

Sample Size Calculation:

In a previous study the response within each subject group was normally distributed with standard deviation 0.142988. If the true difference in the experimental and control means is 0.3, we will need to study 5 experimental subjects and 5 control subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05. ***Khorshid, (2018).***

Methodology:

Epoxy Resin Master Cast Fabrication:

A duplicate of a readymade maxillary edentulous model (figure 1) was fabricated. Silicon mold was fabricated (figure 2) and Epoxy resin material[1] was mixed following manufacturer's instructions and poured inside the silicon mold to fabricate the master cast. Epoxy resin master cast was left to dry for 24 hours. (Figure 3, 4)

This epoxy resin model was used to simulate a clinical condition.

Figure1, Ready made edentulous maxillary cast.

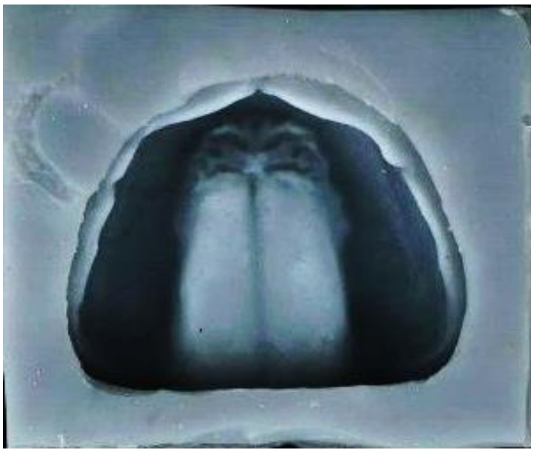

Figure 2, Mould used for epoxy resin cast fabrication.

[1] Egy king epoxy, Egypt

Figure 3, epoxy resin cast fabrication.

Figure 4, Epoxy Resin Master Cast.

Denture Fabrication:

An impression was made for the epoxy resin master cast using medium consistency addition silicone material[2] using a custom-made tray. Then a denture base was used for setting up teeth using conventional method.

Set up of the teeth was used to guide for implant installation at central incisor, canine and second premolar areas bilaterally. (Figure 5)

Figure 5, Denture with full set of teeth.

Implant Installation:

Pilot drill was used to drill holes corresponding to the site of implant installation using the trial denture base, implant direct[3] drilling kit was used to drill holes were inside the epoxy resin master cast in the areas of central incisor, canine and second premolars bilaterally.

six dummy implants[3] were installed in the drilled osteotomies using the dental surveyor by connecting the implant driver to the dental surveyor hock and the implant were placed in the implant driver and using the surveyor's arm, all implants were installed in their prepared sites using soft mix of clear acrylic resin[4]. (Figure 6, 7)

[2] Zhermack elite, Italy.
[3] Implant Direct, USA.
[4] Henry Schein, Spain.

Figure 6, Dental surveyor.

Figure 7, Implant driver connected to surveyor's hock

Implants were installed using a soft mix of acrylic resin that will be inserted in the drilled holes. (Figure 8)

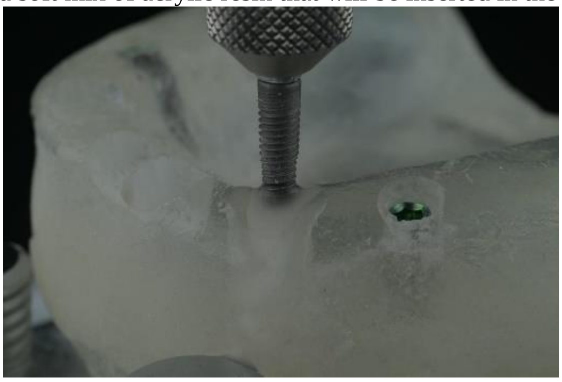

Figure 8, implants installed using soft mix of acrylic resin.

The six implants were installed parallel to each other, the cast was left until the complete setting of the soft acrylic resin.
Each implant was named starting from the right-side A, B, C, D, E, and F. (figure 9)
In this study, using the same master cast, 2 groups of frameworks were fabricated.
Group 1: cast cobalt chromium frameworks using conventional open tray impression technique, Group 2: milled titanium frameworks using intra oral scanner and computer aided milling technology.

Group 1, Casted Framework Fabrication:
open tray transfers[5] having square geometry were attached to the six implants respectively. All torqued according to the manufacturer's instructions. (Figure 9)

[5] Implant Direct, USA.

Figure 9, implants were named, and open tray transfers attached to six implants respectively.

All six implants were connected using dental floss multiple times around each open tray transfer and the subsequent one and were splinted together using flowable composite[6]. (Figure 10)

Figure 10, open tray transfers splinting

.

Stock plastic tray was checked for proper seating with no rocking. A hole was made corresponding to each implant and the open tray transfer was checked to be showing through the tray. (Figure 11)

The impression was made using Poly vinyl siloxane putty and light consistencies[7] by one-step impression technique for the open tray impression. Material was left to set according to the manufacturer's instructions. (Figure 12)

After setting of the material, Open tray transfers were unscrewed, and the impression was removed, and properly checked if there is any separation between the impression material and the tray, and also the impression material was checked to be covering all aspects of the cast, in addition to that, no movement of the open tray transfers inside the impression material was assured. (Figure 13)

Implant analogues[8] were attached to the transfers and whole impression was poured immediately using dental plaster and left for complete setting.

Open tray transfers were unscrewed and Plastic castable abutments[9] were fastened to the analogues.

[6] 3M, USA.

[7] Zhermack elite, Italy

[8] Implant Direct, USA

Waxing up of the framework was done so that entire metal core is sculpted in wax at the precise shape and size to produce a pattern connecting all the implants forming a bar which was then invested and casted into cobalt chromium alloy. (Figure 14)
Same steps were performed to generate 5 frameworks.

Figure 11, Stock plastic tray was checked for proper seating.

Figure 12, one-step impression technique for the open tray impression.

Figure 13, Open tray transfers were unscrewed, and impression was taken off.

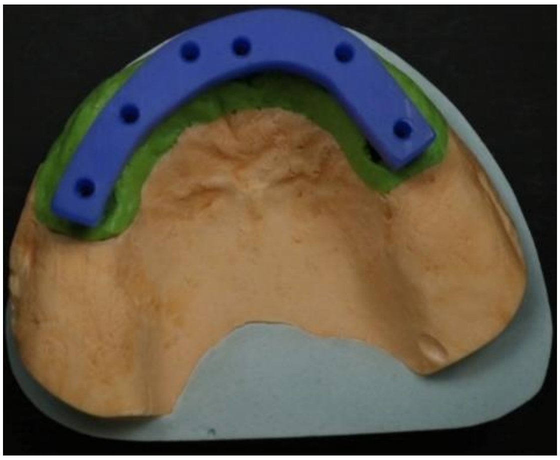

Figure 14, Waxing up of the framework.

Group 2, Milled Framework Fabrication:

Six scan bodies[10] were attached to the six implants A, B, C, D, E, and F respectively, on the same master cast. (Figure 15). An intra-oral scanner and software was used to scan the full cast.

The scans were performed following the manufacturer's instruction for the scan strategy; continuous scanning method with the scanner head held mostly in a horizontal position throughout the scan, and the rotation of intraoral scanners in a vertical direction was minimized. The scanning sequence began from the occlusal surface of the area of the second molar on one side corresponding to implant F, proceeding toward the second left molar of the other side corresponding to implant A, going back scanning the buccal side in the left to right direction and the palatal side in the right to left direction. The scanning was repeated 5 times to generate 5 scans for the same master cast.

[9] Implant direct castable abutments, USA
[10] Direct scan bodies, USA.

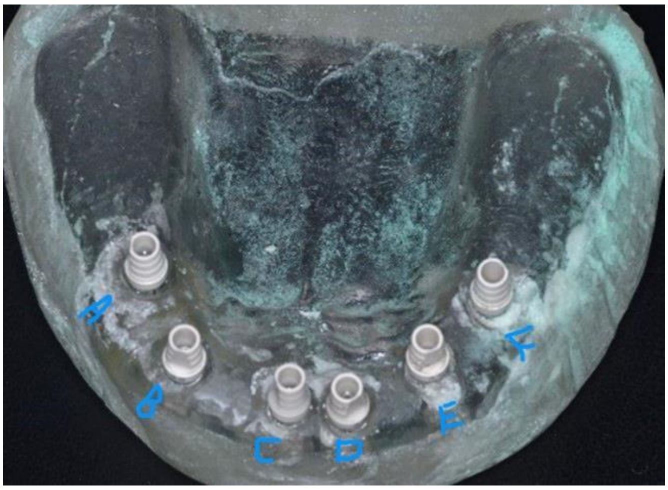

Figure 15, six scan bodies were attached to six implants respectively.

The STL files were exported from the scanner software, and using Exocad software, a standard bar was designed using bar module which allowed fast and accurate shaping of the bar, covering all implants and having cylindrical holes for the bar was designed to fit into non hexed Ti-bases[11]. (Figure 16, 17)
Same designing steps were followed to generate five frameworks.

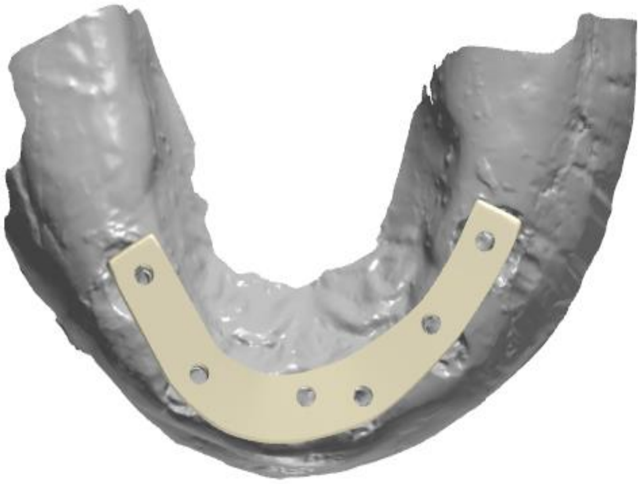

figure 16,17, Standard bar was designed using bar module by Exocad software.

[11] Implant direct Ti-bases, USA

The 5 designs were exported into CAM files and milled using 5 axis CAD/CAM milling machine[12].

The frameworks for both groups were checked individually for fit and passivity using the single screw test following the technique recommended by Sahin and Cehreli. (Figure 18, 19)

The technique involved screwing the most distal abutment of each framework and check for possible lifting of the framework on the other side of the framework which if present, indicated lack of passivity of this framework. In case the framework remained stable in place, the middle screw was then placed, and so forth of the rest of the screws.

After placing screws one by one to ensure that the framework was passively seated, a final 180º turn was performed to reach a torque of 10 Ncm for complete screw seating. In case one of the screws required more than 180 º to provide seating of the screw, the framework was considered misfit.

Detection of any gap by a probe and appropriate lighting was performed.

Figure 18, Milled Farmework.

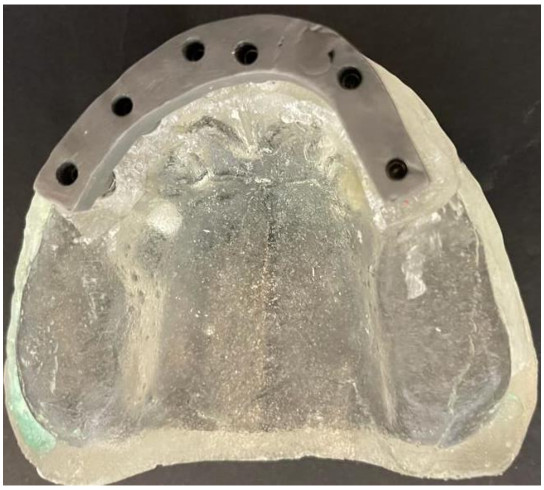

Figure 19, Casted Framework.

In the following study, using stereomicroscope[13] the buccal aspect the frameworks installed over the six implants was checked for the presence of any gap, and the gap distance was measured to indicate the level of passivity under 2 conditions, first when all screws were fully tightened, and when only implant F (the most distal from the left side was fully tightened).

The measurements were done using a zoom stereomicroscope with 3.0-megapixel CCD cameras[14]at a 125x PC-monitor magnification. Calibrated image software[15] was used to measure the vertical gap between the edge of the framework and the implant surface, A trained and blinded investigator analyzed all the images captured and was asked to record 3 measurements at the buccal surface of the framework corresponding to each implant for each of the frameworks of the two groups. (Figure 20)

[12] CORiTEC 150i PRO, Germany
[13] SMZ-1500 Nikon, Japan
[14] Moticam 2300 Motic, japan
[15] Motic Images plus 2.0, lesica software, japan

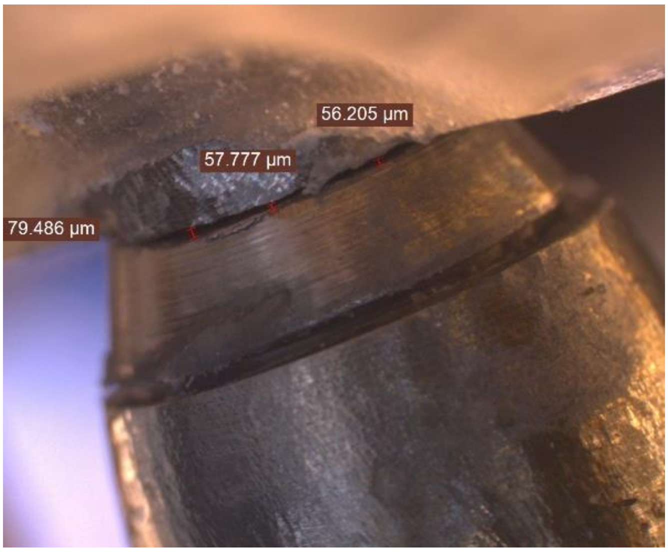

Figure 20, measuring gap distance using stereomicroscope.

The mean gap values of each implant were measured, tabulated, and statistically analyzed.

Statistical analysis

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016.

All quantitative data were explored for normality by using Shapiro Wilk and Kolmogorov Normality test and presented as means and standard deviation (SD) values, and independent t-test was used to compare between both groups. Results were presented as normality test, comparison between group I (casted group) and Group II (milled group) when all implants were fully tightened, and implant F was fully tightened.

III. Result

In this study, all fabricated frameworks were considered passively seated over their corresponding implants in all groups using the one screw test.

Shapiro-Wilk test and Kolmogorov-Smirnov test for normality revealed that the significant level (P-value) was shown to be insignificant as P-value > 0.05, which indicated that data originated from normal distribution (parametric data) resembling normal Bell curve in both groups.

Table (1): Normality exploration of data:

	Casted group		Milled group	
	P value	Indication	P value	Indication
Fully tightened	>0.05	Normal data	>0.05	Normal data
Implant F is fully tightened	>0.05	Normal data	>0.05	Normal data

Comparison between group I (casted group) and group II (milled group) when all implants were fully tightened:

There was no statistically significant difference between the two groups when all implants were fully tightened, and the over all gap distance was slightly higher in milled group than in the casted group. Even though there was no statistically significant difference.

Table (2): Comparison between group I (casted group) and group II (milled group) when all implants were fully tightened:

	Implant	**Group I Casted group**		**Group II Milled group**		**P value**
		M	SD	M	SD	
Fully tightened	A	65.93	9.41	52.63	12.36	0.09
	B	64.54	12.11	67.89	5.65	0.59
	C	59.18	16.80	47.25	2.48	0.15
	D	71.63	11.36	68.67	30.89	0.84
	E	55.33	15.10	64.49	13.01	0.33

	F	53.80	14.17	75.76	10.10	0.33
	Overall	61.74	13.16	62.78	12.41	0.941

M: mean SD: standard deviation
P: probability level which is significant at P ≤ 0.05

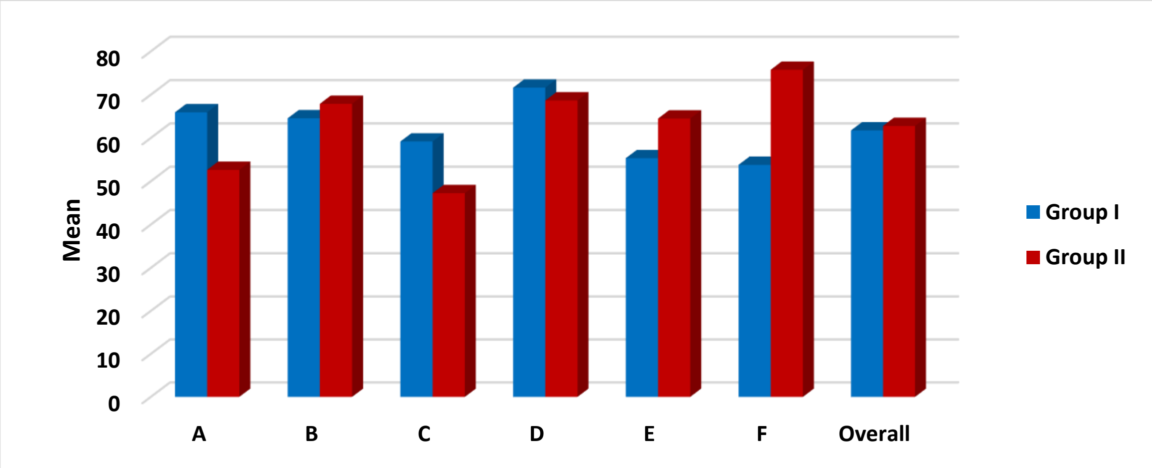

Figure 21, Bar chart showing Comparison between casted and milled groups regarding fully tightened implants.

Comparison between group I (casted group) and group II (milled group) when only implant F was fully tightened:

It revealed a statistically significant difference between the groups regarding implant A, B, milled group showed higher gap values at A (496.83 ± 14.88) and at B (364.47 ± 57.96) and over all there was significantly greater values in the milled group (262.30 ± 38.12) when compared to the casted group (166.12 ± 40.65).

Table (3): Comparison between group I (casted group) and group II (milled group) when only implant F was fully tightened:

	Implant	Group I Casted group		Group II Milled group		P value
		M	SD	M	SD	
F implant fully tightened	A	189.74	55.63	496.83	14.88	<0.0001*
	B	166.41	16.48	364.47	57.96	<0.0001*
	C	293.45	85.32	310.14	40.05	0.71
	D	211.07	42.10	250.77	75.35	0.33
	E	68.02	22.19	73.98	10.16	0.61
	F	68.02	22.19	77.59	30.32	0.58
	Overall	166.12	40.65	262.30	38.12	0.004*

M: mean SD: standard deviation
P: probability level which is significant at P ≤ 0.05

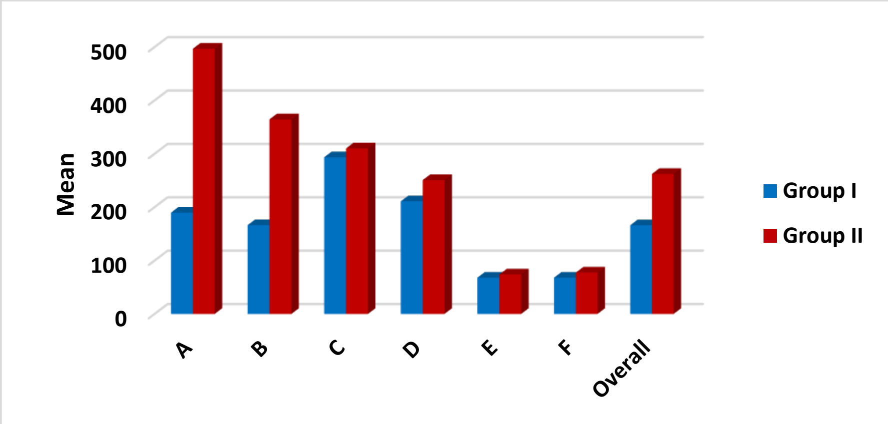

Figure 22, Bar chart showing Comparison between casted and milled groups F implant fully tightened.

IV. Discussion

This study was classified as an in-vitro study, which is considered the lowest reliable evidence, but it is a straightforward research methodology, allowing experimental research to examine the validity of a hypothesis.

In the current invitro study, epoxy resin cast was used, to ensure the best dimensional accuracy, as *Gujjarlapudi et al. (2012)* in a comparative study, compared physical properties of epoxy resin, resin-modified gypsum and conventional type-IV gypsum material, it was concluded that Epoxy resin exhibited superiority in dimensional accuracy, surface detail reproduction and transverse strength and is nearest to the standards of accurate die material.

Most reports recommended number of implants ranging from 6 to 12 in the maxilla *Jemt et al. (2006)* and 4 to 8 in the mandible *Balshi et al. (2015),* our present study was carried out using 6 implants following *Agliardi et al. (2014)* who reported that six implants could be considered as a predictable and cost- and time-effective option.

In the current study, Dental surveyor was used to place the implants in the epoxy resin cast, since *Pande et al. (2014)* mentioned that the dental surveyor is an instrument used to ensure parallelism of two or more surfaces of the teeth or other parts of the cast of a dental arch.

Implants were placed parallel to each other following *Wei et al. (2018)* who conducted a systematic review that stated no differences in clinical performance between implants that are placed in an axial position relative to the residual alveolar ridge when compared with implants that are intentionally tilted toward the distal aspect of edentulous jaws.

Open tray impression technique was used in the current study as *Saini et al. (2018)* conducted a study to determine more accurate impression technique for multiple implant impressions in edentulous patients, it was concluded that open-tray impression technique resulted in more accurate results as compared with the closed-tray technique.

Square impression coping was used as mentioned by *Vigolo et al. (2004)* who evaluated multiple impression techniques for multiple internal connection implants and concluded that an improvement in accuracy of the definitive cast was achieved when the square impression copings were splinted When compared to non-modified copings.

Poly vinyl siloxane material was used in recording the open tray impression in the current study, following *Kurella et al. (2020)* who compared the accuracy and dimensional stability of High-rigid vinyl polysiloxane, polyvinyl siloxane, and polyether impression materials used in full arch implant-supported prosthesis either in splinted and non-splinted conditions, it was reported thar polyether material showed less deviation from the reference model, followed by Poly Vinyl siloxane, and high rigid vinyl poly siloxane. Results proved that there was no statistically significant difference between them. All the three impression materials can be used for making full-arch implant-supported prostheses. In addition to that, Splinting resulted in more accurate results when compared to non-splinting.

These findings were assured by *Alkhasi et al. (2015)* who recommended that both closed tray and open tray techniques had acceptable results with the use of Polyvinyl siloxane, and *Kaur et al. (2023)* who pointed out that Poly vinyl siloxane was found equivalent in accuracy to rigid Poly ether for recording parallel or angulated implants.

Baig (2015) concluded in his systematic review that Poly Vinyl Siloxane and Poly Ether were the most accurate impression materials used for edentulous multiple-implant situations.

Splinted technique was followed in the present study, following *Papasyyridakos et al. (2012)* who compared between splinted and non-splinted technique in edentulous patients, and he proved that the splinted technique generated more accurate master casts than the non-splinted technique for in edentulous jaws. These clinical implications demonstrate improved accuracy of splinted impression techniques compared with the non-splinted technique.

Flowable Composite resin material was used in splinting the impression copings following *Kamrane et al. (2014)* who compared the accuracy of impressions using 3 types of splinting materials: a pattern acrylic resin, an acrylic resin, and a dual-cured composite resin, their findings indicated that the composite resin demonstrated better accuracy than the other tested splinting materials.

Also supported by *Joseph et al. (2018)* who evaluated positional accuracy in multiple implants using four different splinting materials in multiple implants, and they found out that flowable composite as well as bite registration material can be recommended as a splinting material of choice for multiple implant cases.

Papsyrsidakos et al. (2016) conducted a study comparing Digital versus conventional implant impressions for edentulous patients regarding accuracy outcomes. And confirmed that splinted, implant-level impression technique was more accurate than the non-splinted one for completely edentulous patients.

González et al. (2017) identified certain factors that influence accuracy: the amount of visible scan body, distance and angulation between scan bodies, and operator experience.

Andriessen et al. (2014) assessed the accuracy of IOS in edentulous mandibles rehabilitated with overdentures. It was concluded that inter-implant distance and implant angulation were critical factors influencing the accuracy of intraoral scanning.

Marques et al (2014) in a Literature Review studying digital impressions recorded that the accuracy of digital impressions in implant dentistry depends on several aspects. The depth/angulation of the implant, the experience of the operator, the intra-oral scanner used, span of the scanned area and environmental conditions may influence the accuracy of digital impressions in implant dentistry. Also, it was mentioned that scan body design and material, as well as scanning technique, have a major impact on the trueness and precision of digital impressions in implant dentistry.

Kim et al. (2018) compared the trueness (the amount of linear and angular displacements of each implant replica) and precision (the degree of closeness between repeated measurements) of conventional open-tray impressions and intraoral digital scans at the implant level in an edentulous maxillary model with 6 implant replicas using different scan bodies. It was found that conventional splinted open-tray impressions showed the highest accuracy, followed by digital impressions using the CAD/CAM scan bodies with extensional structure while Digital impressions using the original scan bodies and the CAD/CAM scan bodies without extensional structure showed relatively low accuracy.

Different materials are used in scan body manufacturing, Currently, PEEK is the most popular material for commercially available scan bodies. As mentioned in a recent systematic review *Mizumoto et al (2018)*, the materials of a scan body could exert certain influence on scanning accuracy.

In the current invitro study, the scan body was made of peek material, small size and with extensional geometry following an in vitro study by *Mizumoto et al. 2019* that indicated that the accuracy of digital impressions was affected by scan body geometry. It was proved that a shorter and simpler designed scan body might perform better in terms of scanning time and that scan bodies made of peek showed acceptable accuracy when compared to titanium scan bodies.

The manufacturer for each scanner specifies a scanning strategy, although for complete arch scanning, quadrant where the scanning begins is not specified. If a local error occurs during the scanning, cumulative errors may be seen with the stitching process as the scanning continues toward proximal areas. As differences in accuracy may occur between the regions where the scanning starts and ends, the effect of the scanning sequence on accuracy was evaluated by *Diker et al. (2022)* who concluded that the accuracy of complete-arch and 4-unit FPDs digital scans differed depending on the IOS and scanning sequence.

In the current study, we followed the scanning protocol recommended by *Park et al (2019)* who aimed to determine the most reliable scanning strategy, using a new protocol for assessing the accuracy (trueness and precision) of intraoral scan data, they recommended that for obtaining the full arch scan data, a continuous scanning method with the scanner head held mostly in a horizontal position throughout the scan can be used. However, rotation of intraoral scanners in a vertical direction should be minimized.

All screws were screwed according to the manufacturer's instructions following *Al Otaibi et al. (2014)* who studied the effect of 2 torque values on the screw preload of implant supported prosthesis with passive fit or misfit, and he concluded that Increasing the torque value beyond the manufacturer's recommended amount and retorquing of the screws at 10 minutes after the initial torque did not necessarily lead to a significant increase in preload in full-arch implant-supported fixed prostheses, particularly under non-passively fitting frameworks.

Abduo et al. (2011) in a critical review assessing the fit of dental implant prosthesis mentioned that there are three methods for assessing passive fit of implant frameworks, clinical assessment methods including finger pressure, visual inspection, radiographs, tactile sensation, one screw test, screw resistance test and 3D photogrammetry, while modeling methods included photo elastic strain analysis, strain gauge and finite element analysis, furthermore, dimensional methods for assessing fit of implant frameworks included microscopy, photogrammetry and use of coordinate measuring machine.

It was mentioned that the Sheffield test or the one-screw test is an efficient test for clinical evaluation of framework fit. When one screw on the distal abutment is completely tightened without creating a gap between the other abutments and cylinders, the superstructure is said to have a clinically acceptable fit. This technique is especially effective for long-span frameworks, in which the vertical gap tends to be magnified at the opposite abutment. The vertical gap on the unscrewed abutments can be assessed with the aid of direct vision and an explorer.

Rutkunas et al. (2020) mentioned that various techniques have been introduced to assess prosthesis fit. During the clinical evaluation, the framework fit can be evaluated visually, tactilely, radiographically, or with a specific test such as the one-screw (Sheffield) test or the screw resistance test. All currently used clinical methods, however, are subjective, have many variables, and are dependent on the operator's skill, it was also mentioned that Microscopy has been used to evaluate the fit of partial or complete arch implant-supported fixed prostheses connected to implants or multiunit abutments. Under standardized conditions, microscopy measurements can be comparable and moderately accurate.

Although no single method has been universally accepted, limitations can be overcome by combining available fit-assessment methods. In the current study two methods were combined to assess the passive fit of the frameworks: one screw test (Sheffield test) and microscopy using stereomicroscope.

Discussion of the results:

Jemt et al (1996) reported that one of the most crucial factors is achieving passive fit during prosthesis insertion. This is one of the keys of dental implant-supported restorations in functional zones, he added that passive fit reduces long term stresses along the implant superstructure or any related components and protects bone adjacent to the implants.

Kan et al (1999) mentioned that misfit of implant supported restorations may lead to technical and biological complications. The most frequent technical complications have been found to be the screw loosening and loss of retention of prosthetic components, while other complications also include chipping of the veneering ceramic and fractures of the framework. Biological complications such as mucositis or periimplantitis with crestal bone loss can be initiated by increased plaque accumulation and micro-movements at the implant-abutment connection. Such complications can also be induced by the increased strains in surrounding tissues.

Paniz et al. (2013) confirmed that the achievement of absolute passive fit of a full arch implant-supported restoration is extremely difficult because of the various clinical and laboratory procedures involved. Marginal discrepancies are expected to always be present.

In the frameworks fabricated in the current study, the vertical gap was detected under the stereomicroscope when all screws were fully tightened, and when only implant F was fully tightened. It is important to mention that this study examined only the prosthetic step in the full arch process, and that the fabrication of full arch implant framework either by conventional or digital approaches is extremely technique sensitive. (Table 2).

Mangano et al. (2017) mentioned that optical impressions have several advantages over conventional impressions: among them, the most important is the reduction of patient stress and discomfort. Optical impressions, moreover, are time-efficient and can simplify clinical procedures for the dentist, especially for complex impressions. In addition, optical impressions eliminate plaster models, saving time and space, and allowing for better communication with the dental technician. But Regarding accuracy as compared to conventional impressions, optical impressions are equally accurate for individual restorations or 3–4-element bridges on natural teeth and on implants; conversely, conventional impressions still appear to be the best solution currently for long-span restorations, such as fixed full arches on natural teeth and implants.

The only apparent limitation to the use of IOS in implant prosthodontics is that long-span restorations on multiple implants seem to be challenging which indicate that conventional impressions are the best solution for these challenging clinical situations.

Several recent studies comparing between digital and conventional implant impressions found greater error using the digital approach in terms of passivity, accuracy, and precision, *Schnieder et al. (2001)* reported that Passive fit of implant frameworks is related to the accuracy, and precision of the master cast.

Lin et al. (2018) examined accuracy between models fabricated by conventional and intra oral scanners and concluded that digital pathway was significantly less accurate.

In the current study, Results showed no significant difference between casted and milled frameworks when all implants were fully tightened, while overall gap distance was 61.74 microns in the casted group and 62.78 microns in the milled group. Concluding that when all implants were fully tightened, passive fit of all frameworks was considered clinically acceptable. (Table 2, Figure 21). This comes in agreement with *Abldeazem et al (2014)* who mentioned that Gaps of up to 150 microns are suggested and commonly considered as being clinically acceptable, it was concluded the presence of equivalent accuracy errors between digital and conventional technique for full arch impressions when comparing marginal fit of final prosthesis fabricated either using conventional or digital approaches.

In the current study, comparing between casted and milled group when only implant F was fully tightened revealed that milled group showed higher gap values at A (496.83 ± 14.88) and at B (364.47 ± 57.96) and overall, there was significantly greater values in the milled group (262.30 ± 38.12) when compared to the casted group (166.12 ± 40.65). (Table 3, Figure 22).

These results can be explained according to the scanning sequence that started from implant F and ended at implant A in all groups, our claim was supported by *Gimenez et al. (2014)* who scanned an edentulous model with six implants using and found that the quadrant scanned first was recorded more accurately than the quadrant scanned later.

Following studies have demonstrated that compared to partial-arch scanning, full-arch scanning exhibits larger deviations *Joda et al. (2016, 2017), Marghalani et al. (2018), Schepke et al. (2015), Wismeijer et al. (2018).*

A possible explanation is that 3D images from intraoral scanning are produced by the overlap of a sequence of images. Inherent errors generate and accumulate during the stitching process, leading to cumulative deviation in long-span scanning.

Also supported by *Amornvit et al. (2021)* who compared ten current intraoral scanners regarding accuracy, he concluded that the more the scan distance, the less accuracy for all scanners.

Imburgia et al. (2017) asserted that significant differences in trueness were found among different IOS, this indicates that, despite the considerable progress made by the latest generation IOS, scanning a fully edentulous patient remains more difficult than to scan an area of more limited extent, and consequently the design and milling of full-arch restorations based on these scanning data may still present problems.

Finally, Results from the present study comes in agreement with *Gomez et al. (2022)* who compared accuracy between conventional and digital complete arch implant impression technique in an invitro study and concluded that the conventional impression method showed the best trueness and precision when compared to digital scans.

V. Conclusion

Within the limitation of our in vitro study, it was concluded that:

Absolute passive fit cannot be achieved regardless of the type of material and technique used. Further evaluation of the reliability and accuracy of the digital impression approach must be undertaken in both laboratory and clinical settings.

When evaluating the passive fit of an implant supported full arch maxillary framework fabricated using conventional and digital technique, there was a statistically significant higher vertical gap distance for the digitally fabricated milled framework when compared to the conventional casted framework.

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