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Original Article

A Comparison of Passive Fit Between Conventional and Digital Impression Techniques for an All-On-6 Maxillary Framework

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Abstract

Aim: This study aimed to compare the passive fit of full arch superstructure using conventional impression versus digital impression using extraoral scanner.
Subjects and methods: Six implants were placed in an epoxy cast for parallelism in central, canine, and second premolar areas bilaterally. Two frameworks were made: Group 1 with conventional casted framework using open tray impressions, and Group 2 with milled frameworks via digital impressions. Five frameworks were made in each group. Group 1 involved five splinted open tray conventional impressions for the six implants, leading to a casted superstructure framework. In Group 2, scan bodies were used for digital impressions via an extra-oral scanner, creating 5 milled frameworks using Exocad software.
Using the Sheffield test, passive fit was assessed as either passive or non-passive. Gap distance was measured with all implant screws fully tightened and when only the most distal implant was tightened.
Results: All frameworks passed the one-screw test for passive fit. Statistically, milled frameworks showed a smaller mean gap value when all implants were fully tightened compared to casted ones. Casted frameworks exhibited higher gap distances (61.74 microns) when all implants were tightened and (146.30 microns) when only implant A was tightened.
Conclusion: The milled group demonstrated superior passive fit compared to the casted group in both scenarios: when all implants were fully tightened and specifically when implant (A) was fully tightened, indicating the advantage of digital techniques in ensuring a better passive fit for implant-supported full-arch maxillary frameworks.

Keywords: Passive fit, conventional impression, extraoral digital impression, all-on-six concept, maxillary framework.

Introduction

Rehabilitation of the 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.

Although the All-on-four concept for the edentulous mandible reported a high success rate, significantly lower implant success was

demonstrated after 1 year in the maxilla (56%) compared with the mandible (90%) when implants were immediately loaded with an All-on-4 full-arch screw-retained prosthetic bridge[1]. Moreover, the oral hygiene of the hybrid all-on-four fixed restoration is challenging due to the presence of extensive prosthetic flanges which induce more plaque accumulation.

As an alternative to the conventional all-on-four implant concept, it was 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[2].

The accuracy of the impression is considered the main factor influencing the structures' fit and is affected by impression material, impression technique, implant angulation, and the number of implants. An optimal fit of the implant-fixed prosthesis is required for its long-term success. An accurate implant impression is an integral prerequisite for obtaining an accurate master cast which is the key for fabricating an accurately fitting prosthesis.

Splinting of the impression copings before impression-making produces a more accurate definitive cast than non-splinting for both partially and completely edentulous patients.

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.

The passive fit of implant-supported prostheses to the underlying structures is fundamental for the success and survival of the Osseo-integrated prosthesis. Any misfit of the framework to the Osseo-integrated implants, clinically detectable or not, is believed to induce internal stresses in the prosthesis' framework, the implants, and the bone surrounding the implant.

Any incorrect framework may lead to mechanical complications such as screw loosening or fracture and biological complications, which could compromise the bone-implant interface and the homogeneity of the occlusal load.

While the absolute 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.

Materials and Methods

A duplicate of a readymade maxillary edentulous model was fabricated. Silicon mold was fabricated and Epoxy resin material (Egy King Epoxy, Egypt) was mixed following the manufacturer's instructions and poured inside the silicon mold to fabricate the master cast. The epoxy resin master cast was left to dry for 24 hours. This epoxy resin model was used to simulate a clinical condition.

An impression was made for the epoxy resin master cast using medium consistency addition silicone material (Zhermack Elite, Italy) using a custom-made tray. A trial denture base with teeth setup following a conventional manner was fabricated on the epoxy model. Then a complete denture was fabricated following the conventional steps.

Set up of the teeth was used to fabricate a surgical stent to guide for implant installation at central incisor, canine and second premolar areas bilaterally.

Implant Installation:

A pilot drill was used to drill holes corresponding to the site of implant installation using the trial denture base, implant direct drilling kit was used to drill holes inside the epoxy resin model in the areas of the central incisor, canine and second premolars bilaterally.

Six dummy implants (Implant Direct, USA) were installed in the drilled osteotomies using the dental surveyor by connecting the implant driver to the dental surveyor hock and the implant was placed in the implant driver and using the surveyor's arm, all implants were installed in their prepared sites using a soft mix of clear acrylic resin (Henry Schein, Spain).

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.

In this study, using the same master cast, 2 groups of frameworks were fabricated following different impression techniques. Group 1: casted cobalt chromium frameworks using conventional open tray impression technique, Group 2: milled titanium frameworks using extra-oral scanner and computer-aided milling technology.

Six open tray impression transfers (Implant Direct, USA) having square geometry were attached to the six implants respectively. All were torqued according to the manufacturer's instructions.

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 (3M, USA).

The 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.

The impression was made using Polyvinyl siloxane putty and light consistencies (Zhermack Elite, Italy) by the one-step impression technique for the open tray impression. Material was left to set according to the manufacturer's instructions.

After setting the material, Open tray transfers were unscrewed, the impression was removed, and properly checked if there was 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.

Implant analogues (Implant Direct, USA) were attached to the transfers and the whole impression was poured immediately using dental plaster and left for a complete setting.

Group 1 Casted Framework Fabrication:

Open tray transfers were unscrewed and non-hexed Ti-bases (Implant direct non-hexed Ti-bases, USA) were fastened to the analogues. Waxing up of the framework was done so that the entire metalcore was 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 cast into cobalt-chromium alloy (AE Alloys, USA). The same steps were followed to fabricate 5 frameworks.

Group 2 Milled Framework Fabrication:

Six PEEK scan bodies (Direct PEEK Scan Bodies, USA) were attached to the six implants A, B, C, D, E and F respectively, on the same model.

An extra-oral scanner (Medit T310 Extra-Oral Scanner) and software were used to scan the full cast. The scans were performed following the manufacturer's instructions for the scan strategy. The cast was placed on the movable part of the extra-oral scanner which corrects the scanning triangle and performs the accurate scanning. The scanning was repeated 5 times to generate 5 scans for the same master cast to generate STL files.

Framework Fabrication:

The STL files were exported from the scanner software, and using Exocad software, a standard bar was designed using a 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 (Implant Direct Ti-bases, USA).

The same designing steps were followed to generate five frameworks using the milling machine (Maxidon Dental Milling Machine, USA).

The 5 designs were exported into CAM files and milled using 5 axis CAD/CAM milling machine (CORiTEC 150i PRO, Germany).

Measuring Passive Fit:

The frameworks for both groups were checked individually for passivity using the single screw test following the technique recommended[3].

The technique involved screwing the most distal abutment of each framework and checking for possible lifting of the framework on the other side of the framework (Implant A) which if present, indicated a 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. Then, the screw was placed at B then C and so on until reaching F.

After placing screws one by one to ensure that

the framework was passively seated, a final 180° turn was performed to reach a torque of 10 Ncm for complete screw seating. In case one of the screws required more than 180° to provide seating of the screw, the framework was considered misfit[4].

Detection of any gap by a probe and appropriate lighting was performed. The stereomicroscope (SMZ-1500 Nikon, Japan) was used to detect the gap distance at the buccal aspect for all six implants, and the gap distance was measured to indicate the level of passivity under two conditions, first when all screws were fully tightened, and when only implant A (the most distal from the right side was fully tightened).

The measurements were done using a zoom stereomicroscope with 3.0-megapixel CCD cameras (Motican 2300 Motic, Japan) at a 125x PC-monitor magnification. Calibrated image software (Motic Images Plus 2.0, lesica software, Japan) 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. The mean gap values of each implant were then measured, tabulated and statistically analyzed.

Results

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 an independent t-test was used to compare both groups. Results were presented as a normality test, a comparison between Group 1 (casted group) and Group 2 (milled group) when all implants were fully tightened, and implant A was fully tightened.

When comparing Groups 1 and 2 when all implants were fully tightened; there was a statistically significant difference between the two groups. For implants A, B, C and D, Group 1 (conventional casted Co-Cr) showed a greater significant gap distance when compared to Group 2 (Table 1, Figure 1).

Whilst comparing Groups 1 and 2 when one implant was fully tightened (implant at A); there was a statistically significant difference between Group 1 and Group 2. Group 1 showed a greater statistically significant gap distance at implants A, E, F and overall.

Discussion

One of the most crucial factors is achieving passive fit during prosthesis insertion. This is one of the keys to the success of dental implant-supported restorations, in addition to that passive fit reduces long-term stresses subjected to the underlying implants and its superstructure [5].

The misfit of implant-supported restorations may lead to technical and biological complications. The most frequent technical complications were 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 [6].

The achievement of absolute passive fit of a full arch implant-supported restoration is extremely difficult because of the presence of marginal discrepancies within the framework after various clinical and laboratory procedures [7].

In the current study, the passive fit of two maxillary implant-supported frameworks constructed using the conventional (Group 1) and the digital technique utilizing the milling technique (Group 2) was compared when all implants were fully tightened and when only one implant was tightened at one end (at implant A).

In Group 1 the framework was constructed using a conventional open tray impression and casting technique, a greater overall gap distance was present when compared to Group 2 (milled group) when all of the six implants were fully tightened, the overall gap distance recorded for group 1 was 61.74 ± 13.16 compared to 44.89 ± 10.21 microns in group 2 which was not statistically significant (p=0.06). These values are considered to be clinically accepted. The literature reported that 10 to 150 μm are considered to be values for the acceptable vertical misfit. 10 μm was reported as the maximum marginal opening between prosthesis and abutments [8], and from 40

μm to 150 μm was considered to be an acceptable range[9 10 11].

An explanation for the results of the present trial is that the conventional method will result in an accumulation of errors resulting from pouring of the impression, shrinkage of the stone, metal shrinkage, and casting errors, all these errors will eventually affect the passivity of the framework fabricated. It was reported that the conventional cast lost-wax technique, which is used to construct a casted full arch prosthesis will result in porosity, deformation, and warpage which leads to loss of passivity[12 13 14 15]. On the other hand for the milled group a digital impression using an extra-oral scanner was used which eliminated the dimensional inaccuracies of any impression material and also the polymerization shrinkage resulting from pouring of the impression was avoided, in addition to all the inaccuracies from the conventional steps of framework construction was eliminated due to the use of the milling CAD/CAM technology, in addition to that the milled framework will have a better fit and a larger number of contacts with the underlying implant than the cast framework[16] which will result in a smaller gap distance for Group 2.

The achievement of passive fit for a full-arch implant-supported restoration, as a result of the many clinical and laboratory procedures involved, is extremely difficult to achieve, and marginal discrepancies will always be present[17 18 19] and this would explain that there was a statistically significant greater gap distance at implants A, B, C, and D in group 1 when all implants were fully tightened. While when only one implant at one end was tightened at implant A, there was a greater statistically significant gap distance at implants E, and F and the overall gap distance for group 1.

Conclusion:

From the results of the current study, we concluded that the digital impression technique utilizing the milling technology has resulted in a smaller gap distance with better passive fit than the cast one. We also concluded that:

1. Absolute passive fit cannot be achieved regardless of the type of material and technique used.
2. There was a higher vertical gap distance for the conventional/casted framework group when compared to the milled/digital framework group.
3. The digital impression technique utilizing the milling technology has resulted in smaller gap distance with better passive fit.

Table (1): Comparison between Group 1 (casted group) and Group 2 (milled group) when all implants were fully tightened

	Implant	Group 1 Open tray impression		Group 2 Digital impression using Extraoral scanner		P value
		M	SD	M	SD	
Fully tightened	A	65.93	9.41	47.50	12.54	0.03*
	B	64.54	12.11	43.27	9.52	0.01*
	C	59.18	16.80	42.25	8.64	0.003*
	D	71.63	11.36	48.48	4.04	0.002*
	E	55.33	15.10	40.73	14.09	0.15
	F	53.80	14.17	47.12	12.40	0.45
	Overall	61.74	13.16	44.89	10.21	0.06

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

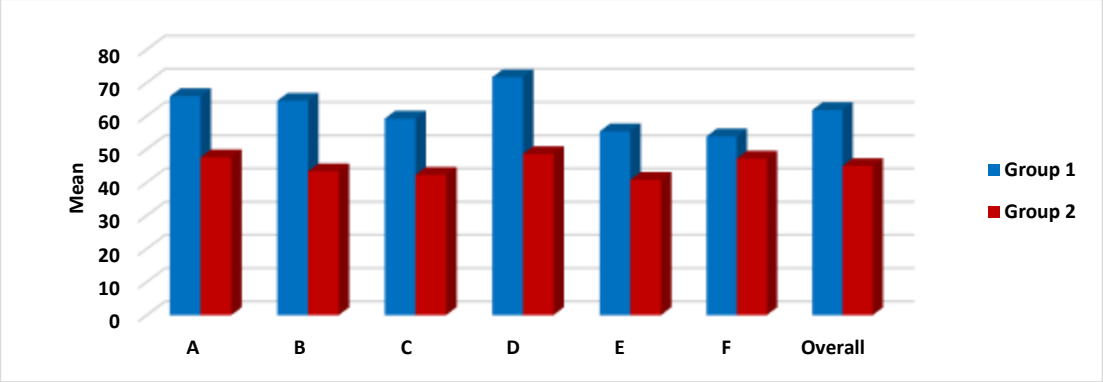

Figure (1): A comparison bar chart between conventional and milled groups (fully tightened)

Table (2): Comparison between casted and milled groups when implant A was fully tightened

	Implant	Group 1 Open tray impression		Group 2 Digital impression using Extraoral scanner		P value
		M	SD	M	SD	
Implant A fully tightened	A	63.43 a	7.45	44.39 a	11.39	0.01*
	B	56.89 ab	24.51	70.50 a	17.87	0.34
	C	89.54 ab	7.57	87.66 ab	16.50	0.82
	D	109.26 b	7.26	94.95 ab	14.57	0.08
	E	217.86 c	35.27	122.23 bc	8.72	0.0004*
	F	359.86 d	17.11	156.12 c	18.23	<0.0001*
	Overall	146.30	17.18	99.15	13.89	0.001*
	P value	<0.0001*		<0.0001*		

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

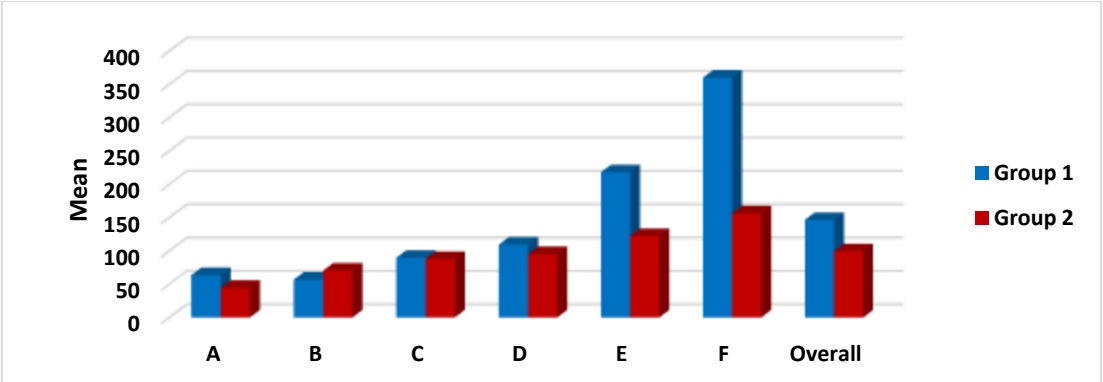

Figure (2): A comparison bar chart between conventional and milled groups (implant A fully tightened)

Conflict of Interest:

The authors declare no conflict of interest.

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Ethics:

This study protocol was approved by the ethical committee of the Faculty of Dentistry - Cairo University on 27 July 2021, approval number: 1-7-21

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