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PASSIVITY OF TRIPLE BAR CONSTRUCTION FOR FOUR IMPLANT ASSISTED MANDIBULAR OVERDENTURE: COMPARISON BETWEEN INTRAORAL SCANNING AND IMPRESSION TRANSFER TECHNIQUE

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ABSTRACT

Objectives: The aim of this study was to evaluate the passivity achieved by different impression techniques, conventional and digital one for implant assisted mandibular bar over denture.

Materials and methods: Each of the eight healthy, fully edentulous individuals received four implants in the mandibular interforaminal space. Two bars were given to each patient, one made using the traditional impression method and the other with the digital impression method. Periapical radiography and the Sheffield one screw test were used to evaluate passivity.

Results: There was a significant difference in passivity between the conventional and the digital impressions which show better results and less gap between bar and terminal implant by one screw test.

Conclusion: Regarding the passivity, digital intraoral scanning technique had more favorable clinical outcomes compared to conventional impressions technique in the construction of bar mandibular overdenture assisted by four implants.

KEYWORDS: digital impression, implant overdenture, implant impression technique.

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INTRODUCTION

Implant assisted mandibular overdentures provide a more stable and functional solution for patients with missing teeth than traditional dentures.[1] Mandibular overdentures supported by four implants have become increasingly popular due to their multiple benefits. The four-implant-supported mandibular overdentures offered improved stability and retention.[2]

Accurate and exact impressions yield well-fitting and functional final prostheses. Nonetheless, various factors can complicate the imprint procedure for implant-assisted overdentures.[3] A key problem is effectively recording the angulation and spatial interactions of the implants, as they are positioned at specified angles and locations to guarantee stability and support for the overdenture. Minor mistakes in the positioning of implants might lead to a poorly fitting prosthesis, adversely impacting the patient's overall function and comfort.[4]

Traditional implant impressions are uncomfortable and are associated with a risk of distortion and gag reflex activation.[5] However, there are some types of traditional implant impressions that are comfortable for patients, such as the plaster impression technique.[6] Furthermore, to maximize the accuracy of traditional impressions, the majority of studies recommend splinting the impression copings, a process that is time consuming and makes the patient uncomfortable because they have to keep their mouth open during impression registration.[7] In addition, the conventional approach is prone to errors during the laboratory process, resulting in inaccurate definitive cast.[8] This consequently results in an inadequate fit of the prosthesis, potentially leading to difficulties including mechanical issues such as recurrent screw loosening, fractured abutments or screws, or failures of the prosthetic superstructure.

Implant failure due to biological problems including crestal bone loss need long-term clinical trials to back up these assertions.[9]

Advanced technology, including intraoral scanners and computer-aided design/computer-aided manufacturing (CAD/CAM) systems, now provide alternate methods for obtaining impressions and manufacturing processes for implant-assisted overdentures.[10] One of the many advantages of the digital impression method for implant-assisted overdentures is that it does away with the need for conventional impression trays, materials, and equipment. Digital imprinting has other benefits, such as the ability to save and retrieve patient data digitally, which eliminates the need for physical storage and makes it easy to retrieve data for things like future reference or prosthetic replication.[11]

MATERIALS AND METHODS

This clinical study included 8 participants, ranging in age from 55 to 65, and was a randomized controlled experiment. The prosthodontics department at Mansoura University's Faculty of Dentistry performed implant-assisted mandibular overdentures as oral rehabilitation for all participants who were completely toothless.

This research was designed using the effective sample size and significance level found in a previous investigation. The preceding inquiry showed that there was a significant difference in prosthesis passivity between two different treatment plans for patients without teeth. The program (G*Power version 3.1.5, Kiel, Germany) was used to determine the patient sample size, which yielded an 80% power. Two bars were placed over dentures made using two distinct impression processes for each patient in the trial. The passivity of each bar was assessed using a periapical radiograph and one screw test of Sheffield.

Two categories emerged from the resulting perceptions. Both the control group and the study group used digital impression methods to create their bars. The first group used conventional impression techniques (CIG), while the second used digital impression techniques (DIG). Inclusion criteria were that all patients had fully healed mandibular residual alveolar ridges that were wide enough and tall enough to allow the placement of four implants of an appropriate size in the interforaminal space. The patients were able to have the bar-retained mandibular overdenture constructed because they had an Angles class I maxillomandibular relation and at least 14 mm of mandibular restorative space. We did not include patients who smoked more than 10 cigarettes daily, had parafunctional habits, had diabetes or another systemic disease that affects bones, temporomandibular joint abnormalities, or neuromuscular diseases.[13]

This research (No. A17060722) was approved by the Ethics Board Committee of the Faculty of Dentistry at Mansoura University. After obtaining written informed permission, the patient's participation was confirmed. Two weeks before implant implantation, each patient had standard full dentures made to help them regain normal jaw mobility. Radiography templates were made by duplicating the patient's new mandibular denture with heat-cured acrylic resin. Dual CBCT scanning was performed on patients by Vatech of Seoul, Korea. Both groups received virtual implants that were created using software technology. The implants, made by Gdental Co. of Italy (JDEvo-Plus), were placed in a vertical and parallel fashion. Using standard tessellation language (STL) files, four implants were designed to be placed in the canine and premolar areas on both sides. Using In2Guide, a fast-prototyping system, four stereolithographic mucosal-supported guides were created for the purpose of implant insertion without the need for a surgical flap.

Anchor pins were used to secure the template to the bone after it had been stabilized in the patient's mouth using a rubber base interocclusal record. After punching circular incisions into soft tissues, a computer-assisted universal surgical kit from On Demand in South Korea was used to perform implant osteotomies. To ensure the initial stability of the implant, a minimum torque of 35 Ncm was used. To ensure the implant was in the correct place, a panoramic radiograph was taken after the surgery. Exactly fourteen

After receiving dentures, patients were told to follow home care instructions, eat soft foods, and not wear dentures for at least two weeks. After that, the sutures were taken out and the mandibular dentures were adjusted to fit the ridge using a strong soft liner (Promedica, Neumunster, Germany). Both eccentric and centric occlusions were improved by the use of selective grinding. After taking a three-month break for recovery. To help the mucosa recover around the implants, the healing caps that came with the implants were attached for two weeks after the cover screws were removed.

This is the conventional view, as stated by **Beumer et al. (2015):** Condensation silicone (Zetaplus / Oranwash, Zhermack, Badia Polesine, Italy), stock trays, and transfer-type (closed tray) impression copings were used to make preliminary impressions after an appropriate healing time. Short transfer-type imprint copings were fastened to the implants after the healing abutments were removed. After taking an imprint, the transfer copings were taken out of the implants, fastened to analogues of the implants, and then imbedded in the impression. The standard procedure for pouring a first impression using type IV dental stone was followed. Each cast surface was treated with a separating medium. Attached to the implant analogues imbedded in the first cast were the pickup-type impression copings, which are open tray designs. Each impression coping was secured with six full turns of dental floss. A matrix was formed around the copings using the dental floss. A resin bar was attached to the four copings using the bead-brush method and a DuraLay low-shrinking resin design (Reliance Dental Manufacturer, Worth, IL.). Having achieved our goal of creating a thick, precise, and low-shrinking acrylic resin bar with a 3 mm cross-sectional diameter, using a cutting disk to span the gaps between the adjacent copings, the copings were sectioned in the center of each resin bar between two copyings. Then, the pick-up We numbered the transfer copyings from one to four in a sequential manner.

The master cast had impression coping and other unsightly undercuts filled in with wax. To ensure a consistent thickness of the imprint material, a modeling wax spacer with a thickness of 2 mm was adjusted and placed over the model. To ensure smooth transfer coping passage and easy unscrewing following impression setting, a mandibular tray was made of auto polymerized acrylic resin from Acrostone Manufacturing & Import Company in Cairo, Egypt. The tray was designed with openings opposite each long transfer. After screwing long transfer copings with duralay into the implant fixtures, a periapical radiograph was taken to check that the transfers had been suitably adapted to the cervical anatomy and that all components were sitting correctly. A little quantity of resplinting duralay was applied directly into the mouth using the bead-brush method. A special tray was then used to ensure that the transfer could travel through the holes in the tray without any hindrance. As a result, 2 millimeters of copying material emerged out the tray's apertures. To make sure the denture extensions on the buccal shelf are perfect and that the retromolar pad is covered appropriately, a special tray was molded with green compound around the edges.[15]

After all transfer coping points had been pushed against the ridge, the last medium body rubber base imprint was set in the tray and left there until they exited through the holes. After the imprint material had completely set, the excess material was removed from the access holes of the transfer copings, and the long copings were unscrewed from the apertures of the trays so that they could be retrieved together with the impression material. To ensure that the implant mimics would not move about while the impression was being filled, they were attached to the transfer copying using impression posts and fastened together with a toothpick. Separating medium was applied to the final impression, A tissue mask was applied around copings and the impression was poured At that point we had a master implant cast with 4 implant analogues and a tissue mimic around analogues .for digitalization of the cast, A scan body (Scan Body JDEvo-Plus, Gdental Co., Italy) that replace the traditional impression coping was connected to the implant analogues on the cast with flat surface of the scan body facing labially and torqued at 15Ncm. For standardization, the scanning was performed using the digital intraoral scanner (Medit I700 Intraoral Scanner, model MD-IS0200, Medit Corp., Korea) that was used for the digital intra-oral impression. The resulting 3D scans were then exported in the standard tessellation format (STL).

On the same visit digital impressions were made by intraoral scanner (Medit I700 Intraoral Scanner, model MD-IS0200, Medit Corp., Korea) and scan bodies (Scan Body JDEvo-Plus, Gdental Co., Italy) that replace the traditional impression coping which connected to the implant fixtures. To obtain a virtual master cast (STL) file. According to **Yan et al.**[16] which was applied in our study as following: Without scan bodies, the first step of intraoral scanning was to position the light source perpendicular to the occlusal plane, starting with the posterior implant on the left and moving towards the canine implant on the right (contralateral side). Finally, the scanner was moved to the left side's first premolar implant, tilted toward the lingual side, and moved across the occlusal plane to the buccal side. After that, it was moved from its original spot on the left to the right-hand anterior implant, all while trying to keep the camera perpendicular to the occlusal plane. Any absent sections in the image were rectified by swiftly scanning the pertinent areas. The identical scanning procedure was executed on the opposing half. The area between the two canine implants, identified in both separate scans, was utilized by the software's stitching technique to seamlessly merge the two segments.

A subsequent intraoral scan was conducted utilizing the same methodology, this time incorporating scan bodies to generate a virtual master cast tailored for them.

The bar measurements were mostly established based on the permitted restorative space, biomechanical principles, and hygiene requirements using Exocad software. Titanium bars were produced using the selective laser melting (SLM) 3D printing technique.

While the patient was chewing, the single screw test of Sheffield was used to determine how passivity the bars were. An evaluation is carried out on the other side after a single screw is placed in the final dental implant abutment. If the bar is elevated or has a lip, as determined by radiographs and clinical examinations. Intraoral radiographs were obtained using the paralleling technique and an X-Ray Film Holding Set manufactured by the Shanghai, China-based Alwings Medical Instrument Company. A custom-made plastic film holder was used to ensure that the implants were consistently captured in the intraoral radiography. It was succeeded by the Abdel-Khalek EA17. This adjustment made it possible to get consistent intraoral radiographs by keeping the cone and implant at a constant distance from one another and the implant from the film. Our X-ray equipment (ORIX70s, Ardet Srl, Milano, Italy) was set at 70 kVp, 8 mA, 0.144 kW, and 0.25 seconds for each radiograph. We used the same digital film for each one.

The software used to mark the points and lines was SCANORA Lite program 3.2.6, developed by PaloDEx Group in Finland. Identifying the magnification problems was made possible by comparing the real dimensions with the radiographs. The gap height was calculated by dividing the actual fixture diameter by the radiographic fixture size, as seen in **(figure. 1 & 2).**

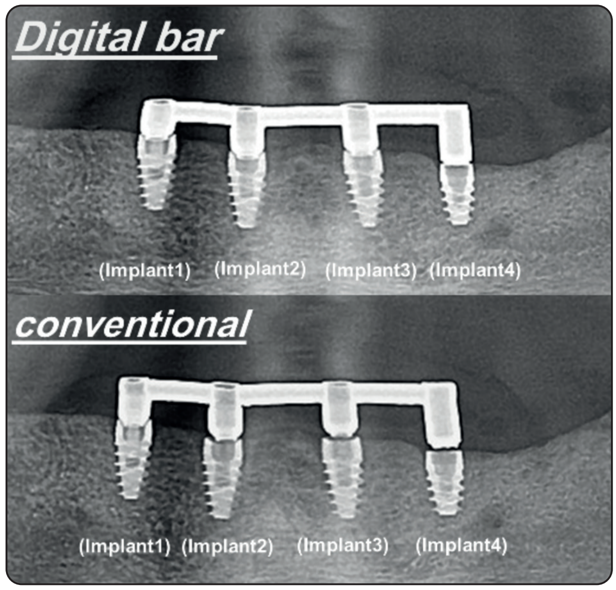

Fig. (1). Panorama radiograph

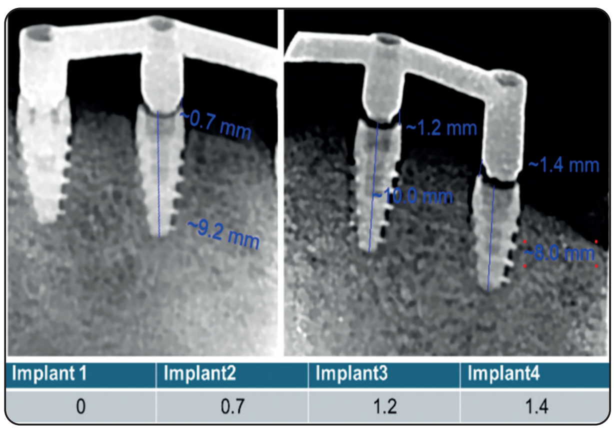

Fig. (2) Evaluation of the bar gap by periapical radiograph

The Shapiro-Wilk test was used to assess the normality of the data distribution. The gap data was non-parametric and did not conform to a normal distribution. The descriptive statistics of gap data include the mean, standard deviation, median, minimum, maximum, and range. The Mann-Whitney test was used to examine the differences between groups. The Kruskal-Wallis test was used to compare the differences between implants. The Mann-Whitney post hoc test was used for the numerous comparisons of the gaps between each pair of implants. A P value is considered significant if it is less than 0.05. The data was processed using SPSS (Statistical Package for the Social Sciences, version 25).

RESULTS

The comparison of the gap (in mm) across groups for each implant is provided in **(Table. 1). (Figure 3).**

There was no significant change in the distance between groups for implant 1 and implant 2.

There was a considerable disparity in the gap between groups for implant 3 and implant 4. The conventional group had a substantially larger gap than the digital group for implant 3 (p = .046) and implant 4 (p = .042).

The comparison of the spacing (in mm) between implants for each group is provided in **(Table. 1) (Figure 4).**

For both groups, the most significant gap was seen with implant 4, followed by implant 3, then implant 2, with the least gap recorded for implant 1.

For the conventional group, a significant difference in the interval between implants was observed (p = .025).

For the digital group, there was no notable change in the distance between implants. Multiple post hoc comparisons between each pair of implants are shown in the same table using the Mann-Whitney test.

For the conventional group, a significant difference was seen in the gap between implant 1 and implant 4 (p = .027) and between implant 2 and implant 4 (p = .047). Nevertheless, no substantial difference was seen in the gap among the other implants.

TABLE (1) Comparison of gap (in mm) between groups and implant

	Conventional group M (min-max)	**Digital group M (min-max)**	**Mann-Whitney test P value**
Implant 1	.00 (.00-.00)	.00 (.00-.00)	1.00
Implant 2	.50 (.00-.70)	.00 (.00-.50)	.346
Implant 3	.70 (.70-1.2)	.40 (.20-.50)	.046*
Implant 4	1.4 (.08-1.50)	.70 (.30-.70)	.042*
Kruskal Wallis test P value	.025*	.071	
Implant 1-implant 2	1.00	.369	
Implant 1-implant 3	.332	.897	
Implant 1-implant 4	.027*	.295	
Implant 2-implant 3	1.00	.951	
Implant 2-implant 4	.047*	.357	
Implant 3-implant 4	1.00	.125	

M; median, min; minimum, max; maximum, *P is significant at 5% level

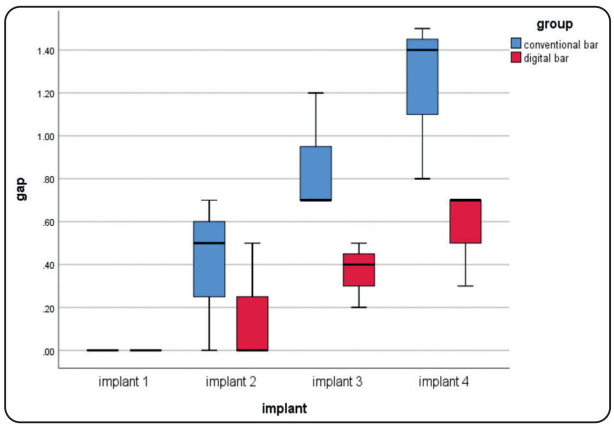

Fig. (3) Comparison of gap (in mm) between groups for each implant

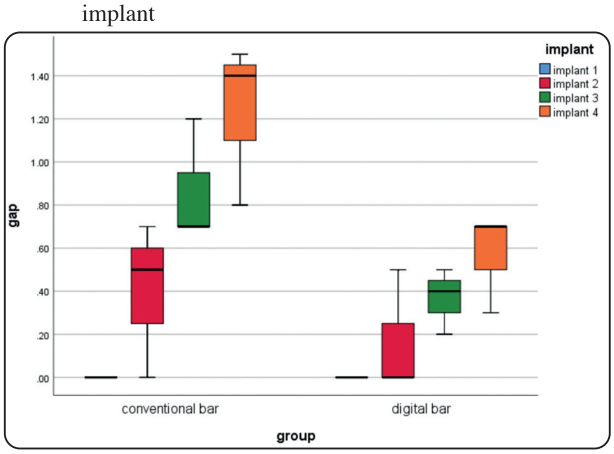

Fig. (4) Comparison of gap (in mm) between implants for each group

Total gap for all implants

Comparison of total gap for all implants (in mm) between groups is presented in **(table. 2) (Figure. 5).**

There was a significant difference in total gap for all implants (in mm) between groups.

Conventional group showed significant higher total gap than digital group.

TABLE 2. Comparison of total gap for all implants (in mm) between groups

	M	min	max
Conventional group	.70	.00	1.50
Digital group	.25	.00	.70

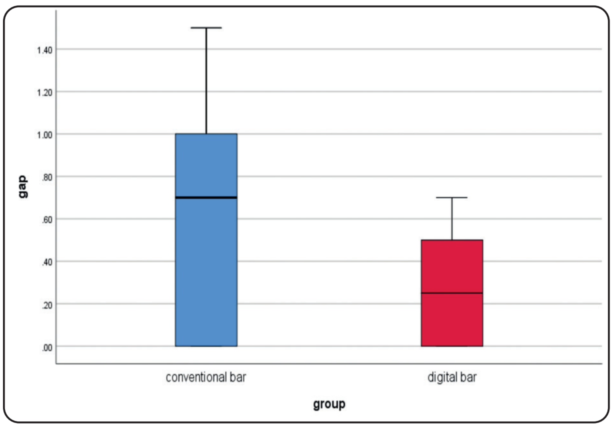

Fig. (5) Comparison of total gap for all implants (in mm) between groups

DISCUSSION

While 100% passive fit of implant prostheses is unattainable, it is essential to reduce discrepancies at the implant-framework interface. The Sheffield test is a prevalent technique for identifying clinically significant misalignments in implant frameworks. In this work, we used the Sheffield test with radiographic examination to assess the gap size at the implant-bar interface.

The findings of this research indicated that there was no significant difference in the gap between groups for both implant 1 and implant 2. A substantial change in the distance between groups was seen for implant 3 and implant 4.

The conventional group had a considerably larger gap than the digital group for both implant 3 and implant 4.

A reduced bar elevation and narrower gap indicate an improved fit and a more passive prosthesis.

Based on the findings of this research, digital intraoral scanning may be regarded as more precise than traditional impressions of edentulous arches, resulting in a more passive fit for prostheses.

The result may be ascribed to the use of intraoral scanners, which provide exceptional accuracy and precision in capturing features, hence improving the fit and marginal adaptation of the implant-supported overdenture. Another justification is that traditional imprints may be prone to distortions and mistakes owing to many factors, including material shrinkage, difficulties in precisely capturing the position or angulation of the implants, and the pouring process. Such errors may result in ill-fitting prostheses.[19]

The findings of the systematic investigation by **Joda et al.**[20] corroborate this theory, since they demonstrated that the digital workflow is superior to the traditional method for implant-supported prostheses. For implant-supported overdentures, the digital impression method allows for non-invasive scanning of the region. In doing so, it is possible to lessen the likelihood of inflammation or harm to the peri-implant soft tissues, which might preserve their health.

Many studies have shown that digital impressions may be more accurate than traditional ones. Trueness, or how well the digital model matches the actual oral tissues, and precision, or how reliable the measurements are, are two common ways to quantify accuracy. These results are in agreement with those of **Menini et al.**[22] and **Amin et al.**[21], who showed that digital full arch implant impressions are much more accurate and true than traditional impressions made with the splinted open-tray technique in an in vitro comparison study. Both groups also found that digital impressions are more precise than traditional methods.

Moreover, **Albayrak et al.**[23] and **Alikhasi et al.**[24] revealed that all digital impression groups produced better results in terms of trueness compared to traditional impression techniques. The results contrast those of **Revilla-León**[25] and **Kim et al.**[26], who found that traditional open-tray impressions significantly decreased linear displacements compared to digital scans obtained with an intraoral scanner at the implant level in a complete-arch model. This corresponds with **Moura et al.**[27], who indicated that traditional splinted open-tray impressions exhibited greater precision than digital impressions for full-arch implant recovery.

CONCLUSION

Digital intraoral scanning is seen as more advantageous and achieves superior passive fit compared to conventional impressions for the fabrication of a four-implant supported overdenture bar.

Ethics Information

The local ethics committee authorized the study procedures (No. A17060722).

Funding

The research was entirely self-financed.

Data Availability

Data is available via corresponding author.

Conflicts of Interest

There is no conflict of interest.

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