THE FIT ACCURACY OF REMOVABLE PARTIAL DENTURE METAL FRAMEWORKS FABRICATED USING INTRAORAL SCANNING OF MOUTH PREPARATION VERSUS CONVENTIONAL IMPRESSION TECHNIQUE. CONTROLLED CLINICAL TRIAL

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ABSTRACT

Aim of this study: The aim of this study was to compares the clinical efficacy and accuracy of RPD frameworks made with intraoral scanning technology to those made with traditional impression procedures.

Material and methods: This clinical trial was conducted on 8 partially edentulous patients so that each one received two frameworks; one fabricated using intraoral scanning technology (group A), the other one fabricated with traditional impression procedures (group B). All frameworks were fabricated using lost wax technique of CO-CR. The gap between the rests and their respective seats was measured using 3D analysis software for the 16 resultant frameworks. Clinical visual inspection was done for all frameworks by expert clinicians. For statistics, data were compared using Paired T-test P < 0.05.

Results: The collected values were tabulated and statistically analyzed. The results showed that, there was no statistical significant difference (P = 0.083) between the groups.

Conclusion: Intraoral scanning can be a simple and useful technique with good fit accuracy in removable partial denture construction.

KEYWORDS: Digital scanning, partially edentulous, accurate fit.

INTRODUCTION

For partially edentulous patients, removable partial dentures (RPDs) play an essential role in restoring masticatory function, esthetics, and overall quality of life. Up to date, removable partial dentures (RPDs) are still in use to replace missing teeth, improving function, with an excellent cost effective treatment for patients who are unable to

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pay for fixed prostheses or dental implants or who are not good candidates [1]. RPDs are fabricated using lost wax technique and are made of cobalt chromium (Co-Cr) alloys. Those conventional methods, while commonly employed, are usually recognised for its intricate nature, lengthy duration, and susceptibility to procedural mistake [2].

The most important factor in RPD is its fit inside the patient mouth. For RPDs to fit and work properly, mouth preparations must be accurately registered using conventional techniques. Traditional impression methods use materials that are prone to dimensional changes during the setting process and subsequent handling, such as silicone or hydrocolloids. These errors may result in misfits in the finished prosthesis, necessitating further modifications and possibly jeopardizing the denture's overall functionality [3].

Recently there are different ways for fabricating RPD's frameworks without casting have been introduced. Technology is constantly evolving, enabling the production of RPD frameworks using numerous digital systems, resulting in more precisely fitted prosthesis as reported in literature [4],[5]. For instance, digital technological developments recently have brought intraoral scanning and computer-aided design/computer-aided manufacture (CAD/CAM) systems, which have completely changed prosthodontic procedures. The production of dental prosthesis is now more accurate, effective, and repeatable because of these advancements.

According to a systematic review, it was found that the misfits and mismatches found in in vitro and clinical studies of the digital technology in RPDs were within the acceptable clinical limit for RPDs and that increased the accuracy of the digital technique for RPD frameworks [6].

One of the recent methods is the use of intraoral scanning instead of the conventional secondary impression. Intraoral scanners greatly enhance the quality and fit of prostheses by accurately capturing the morphology of both soft and hard tissues [7]. Furthermore, the use of 3D printing technology in the creation of RPD frameworks has improved these procedures' precision and efficiency even further, providing a strong substitute for traditional techniques [8],[9]

Despite these advancements, challenges still exist, especially in obtaining the best possible fit and functionality for RPDs [6]. The exact modifications of abutment teeth, including the preparation of guiding planes and rest seats, are crucial to the effectiveness of these prostheses. Even though these processes are essential to the stability and retention of RPDs, they are frequently challenging and time-consuming. However, employing specialist software and digital scanners has shown promise in simplifying these processes, which lowers mistakes and improves the final result [10].

On the other hand, laboratory errors are significantly reduced by digital techniques like intraoral scanning and CAD/CAM systems, which also do away with the impact of impression materials' dimensional stability [11]. These technologies decrease the number of steps needed in traditional procedures, consequently lowering the risk of errors connected with manual manufacturing processes, pouring stone models, and producing impressions by taking very accurate digital impressions directly from the patient's mouth [6]. Additionally, since digital data are not impacted by the same environmental conditions that might alter physical materials, the initial scan's accuracy is maintained throughout production. As a result, the RPD framework fits the patient more precisely, boosting patient satisfaction and outcomes [12].

According to the literature, available evidence regarding the superiority of intraoral scanning (IOS) is insufficient , however the few available evidence reported that the use of IOS is in RPD is associated with better framework fit accuracy and

better denture retention compared to conventional workflows, and digital workflows combined with conventional impressions [13].

The aim of this study is to compares the clinical efficacy and accuracy of RPD frameworks made with intraoral scanning technology to those made with traditional impression procedures. The goal is to determine if digital scanning techniques may significantly improve the fit and functionality of RPDs, making partial denture fabrication more dependable and patient-friendly.

MATERIALS AND METHODS:

The present study was a Controlled Clinical Trial carried out in the faculty of Dentistry Cairo University.

Sample size was calculated using the (G*power software). As regarding the primary outcome (accuracy of fit of the occlusal rests of partial denture frameworks) we found that 8 patients was appropriate sample size for the study. The power is 80% and α error probability =0.05. The magnitude of the effect to be detected was estimated as the mean and standard deviation of the variable of interest and obtained from the scientific literature(9).

Patient Selection

8 partially edentulous patients with a mean age of 40 were selected from the outpatient clinic. All participants were informed about the study procedures, and informed consent was obtained and signed. The clinical trial was carried out after the approval of The Faculty of Dentistry Cairo University Ethics Committee.

Specific inclusion and exclusion criteria were employed to select the patient sample for the study. The inclusion criteria for the study were partially edentulous patients with missing more than two teeth on a free end side and modification area on the other side requiring RPD, at least one premolar or molar for occlusal rest preparation must be present, main

abutment teeth without any periodontal disease, no mobility, 1:1 crown root ratio, alveolar bone loss less than half of the tooth root. Patients with Angle's class I relation. The edentulous area should have firm mucosa with no signs of periodontal disease, pathological conditions, or inflammation. The exclusion criteria included cases where the main abutment teeth were periodontally affected, there are few remaining teeth or the last abutment is not premolar or molar, the dental arch with jawbone and soft tissue defects, patients with parafunctional habits, bruxism, class III malocclusion, and edge-to-edge cases.

Two RPD frameworks were fabricated for each one of the participants using the two techniques, either the intraoral scanning (the intervention) or the conventional impression (the control).

For all the patients who were eligible for the study, periapical radiographs were taken for all the main abutments, followed by primary impressions for both jaws and a diagnostic jaw relation. Then, the casts were mounted on a semi-adjustable articulator for proper diagnosis. The study casts were surveyed using a dental surveyor, and the design was drawn.

For both groups, tooth preparation, including rest seat preparation and creation of undercuts and guiding planes, was done by the same clinician.

Clinical workflow for the intervention group:

For group A, intraoral scanning using a Medit i700 intraoral scanner was done for the whole arch, including the mouth preparation and the edentulous area. The resultant standard tessellation language (STL) file was digitally surveyed using Exocad software (EXO; exocad GmbH, Darmstadt,Germany), which allows for the accurate positioning of RPD components. A specific path of insertion was selected, a survey line was made automatically, and the depth of the undercut was accurately measured and marked. The undesirable undercut areas were virtually blocked out. RPD

framework components such as clasp, rest, and minor and major connectors were designed with the aid of digital designing software according to the principles of RPD design, forming an entire framework design with all components combined. A support structure was added to avoid deformation of the framework during fabrication. The 3D data of the RPD framework were exported as an STL file. The resin framework (3D printing UV sensitive resin, China) was printed from castable resin then was tried in the patient's mouth. Using the lost wax technique, the printed resin pattern was converted into Co-Cr framework *(Fig.1)*.

Clinical workflow of the control group:

For group B, all the steps of the RPD fabrication were done conventionally. The final impression was made by the use of custom made acrylic tray. Polyvinyl siloxane impression material (Zhermack, Italy) was mixed and adapted inside the tray then the tray was loaded, seated in the patient's mouth and the material was molded. The impression was then poured using type IV extra hard stone (Lascod SPA, Sestafino, Italy) by a dental technician, following the manufacturer's processing and setting times. Finally the framework was fabricated in CO-CR using the lost wax technique.

After an intraoral trial of the frameworks for both groups, each framework was seated on its respective master cast *(Fig.2)* for outcome measurement.

The rest of the clinical and laboratory steps were completed for both groups in the same conventional way until the insertion of the final RPD.

Outcome measurement:

(a) Clinical visual inspection:

All frameworks were tried in clinically to evaluate the fit by visual inspection. In order to do that, the try in was done by the same prosthodontist, who was blinded to whether the framework is the intervention or control group. In this step the framework was randomly divided. A simple

randomization procedure was used. Allocating frameworks in either the intervention group or control group was performed with a computerized random allocation program. A computer-generated list of random numbers was obtained for both groups. The researcher was informed about patient allocation only at the try in stage.

Visual inspection was done following guidelines presented in table (1) as proposed by a previous study by Frank et al (14). The frameworks were seated intraorally and a pressing test was done using a plugger which was held on the occlusal rest perpendicular to the occlusal plane, and appropriate pressure was applied on each rest, then any detectable movements was observed.

TABLE (1) Criteria used to clinically evaluate removable dental prosthesis frameworks

All rests are fully seated as prepared and designed. No discernable difference between tooth and metal rests.
All guide plates contact proximal tooth surfaces.
No detectable rock on major connector except on Kennedy class I and Kennedy class II due to tissue stop.
Circumferential clasp has continuous contact around the abutment tooth.
I-Bar has contact from from depth of undercut to height of contour.
Lingual plating has no discernible space between teeth and framework.
No detectable opening from periphery of the major connector to soft tissue.

(b) Accuracy of fit measurement:

The accuracy of fit of the RPD frameworks was assessed by measuring the gap between the occlusal rests of the 16 frameworks and their respective rest seats by the use of superimposition software (Medit design software-Seoul, South Korea) *(fig.3)*. All frameworks were scanned after being coated with scanning spray (Zirko Scanspray; Zirkonzahn GmbH). The master cast and the master cast with the framework seated on it, and the framework alone were scanned using desktop scanner producing

three individual STL files followed by digital superimposition and direct measurements on the Medit design software. Blender for dental software (Dental CAD software version 1.1.24 Australia) was used to perform alignment of the scans. Alignment was achieved using surface matching by selection of specific areas for surface matching. Then the data were introduced to Medit design software for deviation measurement.

For Statistical analysis, a commercially available software program (SPSS Chicago, version 26, IL, USA) was used. The data showed a normal distribution according to the Kolmogorov-Smirnov test. The mean and standard deviation were used to describe numerical data. Data were compared using Paired T-test. $P < 0.05$ was chosen as the level of significance. All tests were two-tailed.
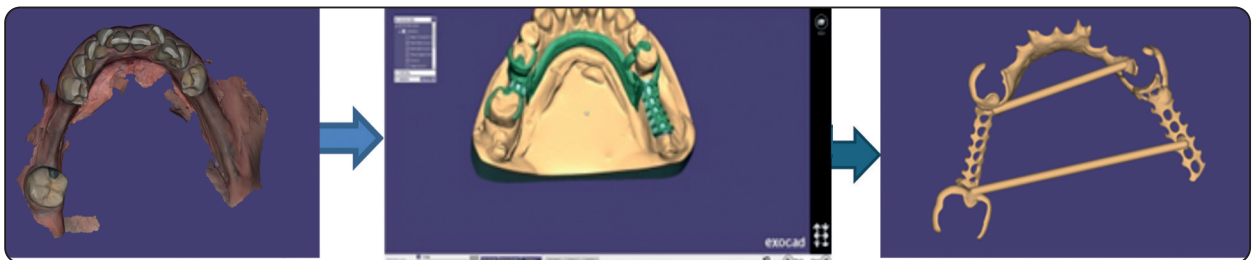

Fig (1) Digital workflow; a) The intraoral scanning, b) Digital wax pattern, c) The framework

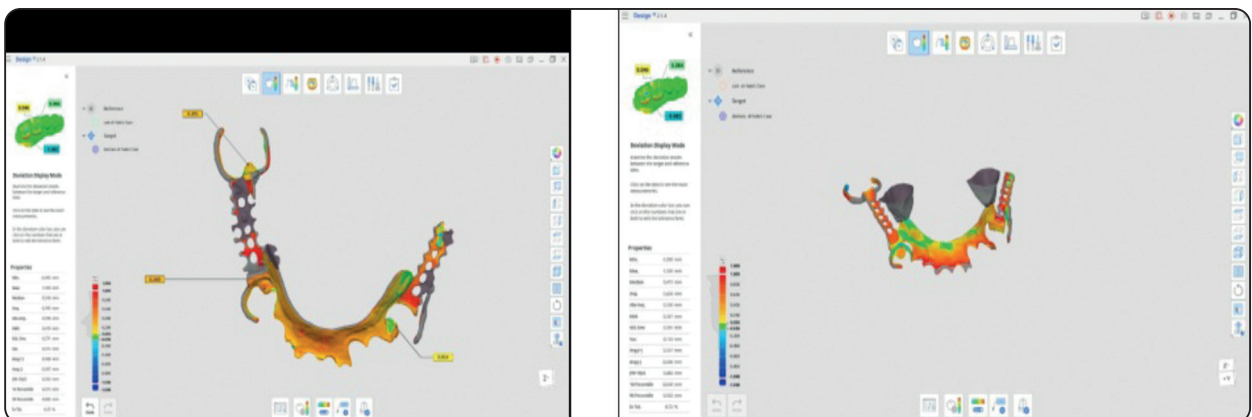Fig (2) The final framework on its respective cast; a) group B on stone cast, b) group A on the printed cast

Fig (3) Deviation measurements using the Medit design software.

RESULTS

A total of 8 patients, with age range of 40 years, were included in this clinical trial. In the 8 cases, 2 maxillary RPDs and 6 mandibular RPDs were involved, including 4 mandibular cases of Kennedy Class II, and 2 cases of long span Kennedy Class III. One of the maxillary cases was long span Kennedy class III and the other one was Kennedy Class IV. A total of 49 occlusal rests were included in the measurement for the 16 RPD frameworks.

Regarding the visual inspection, all the 16 RPD frameworks met the clinical requirements of RPD when tested clinically on the patients in such a way that; all rests were seated on their corresponding rest seats, all rigid component appropriately contacted the teeth related to the RPD and the major connectors did not press underlying soft tissues. In addition, on applying alternative pressure on occlusal rests, there were no detectable movements.

Regarding the accuracy of fit occlusal rests, Paired T-test was performed to assess the statistical difference between the control (group B; frameworks made with traditional impression procedures), and the intervention groups (group A; RPD frameworks made with intraoral scanning technology). Data were presented as mean and standard deviation (SD) values. The test showed that there was no statistical significant difference (P = 0.083) between the two groups. The control group showed higher mean (0.548 ±0.013) compared to intervention group (0.411 ± 0.169) *(Fig.3)*.
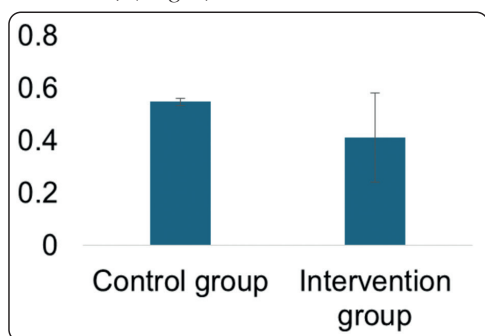

Fig. (4) A bar chart showing Framework represented by mean and SD. Same letter means donates no statistical significant difference. Paired T-test was used with significance p < 0.05.

DISCUSSION

The accurate fit of removable partial denture (RPD) is a major factor of success of the removable prosthodontics. Removable partial denture frameworks misfit has been identified as one of the major problem of RPD wearers [15]. The misfit could be due to poor laboratory procedures, or a distorted impression. Impression making in RPD construction is a very crucial step during which it is difficult to avoid errors that most commonly are due to deformation of the impression [16]. New recent technologies have been employed in RPD construction which is more simple, with better fit accuracy and were introduced to overcome problems of conventional methods [11].

In terms of data acquisition techniques for digital fabrication of the RPD framework, there are two possible techniques; intraoral scanning and extraoral scanning. Intraoral scanning is proved to be beneficial because it associated with higher patient comfort, decreased possible errors that are associated with the conventional impressions, and useful in difficult cases like severe gag reflex. In addition, there is recently a good evidence supporting the use if intraoral scanning in prosthodontics with promising results [17].

A clinical study was done to compare between the direct intraoral scanning in RPD cases and the extraoral scanning of the physical models after conventional impression and it was found that the intraoral scanning was significantly better than the extraoral scanning in framework fabrication. In addition, they found that the conventional impression was better that the extraoral scanning [9]. However, this study used a yes/no survey with 7 framework-related parameters which was done by 5 clinicians.

To the knowledge of the author, most of the clinical trials used the desktop scanning and mainly evaluated the digital technology of RPD fabrication whether it is selective laser melting or direct milling of the framework material or any

other technology[6,4,13]. Only few clinical trials were carried out to investigate the use of intraoral scanning in RPD cases.

The aim of this clinical trial was to investigate the use of intraoral scanning of the mouth preparation and saddle area in partially edentulous cases instead of the conventional impression in order to minimize the error that may be caused by the conventional impression. The gap between the rest and its respective rest seat was measured as this gap can reflect the clinical fitness of RPD frameworks as reported in many studies [5, 18, 19]. Therefore this clinical trial focused on measuring that gap and it was found to be less in group A (the intraoral scanning group) than in group B (the conventional impression group) but the difference was statistically insignificant.

One clinical study was done to evaluate the use of computerized optical impression making in RPDs in terms of the whole jaw, mucosa with residual teeth, isolated mucosa, and isolated abutment teeth and it has reported that, recording dental hard tissue using the optical impression is satisfactory than the conventional impression but not that accurate in recording the mucosa. However, they justified that discrepancy in such a way that, the software algorithms automatically filter out mobile tissues [20].

The results of the presented clinical trial were similar to another trial which investigated the use of intraoral scanning. The trial reported that, the digital workflow for removable partial denture framework fabrication is an accurate alternative to the conventional one and that intraoral scanning was significantly better than the conventional method or when combining both conventional and digital methods of fabrication together [9].

On the other hand, another clinical study evaluated the fit accuracy of removable partial denture metal frameworks produced by CAD-CAM and reported no statistically significant differences between the digital group and the conventional group. However, in that study the impression was made in conventional way and the obtained stone cast was scanned by laboratory scanner and the assessment was done by the use of silicone replica [21].

Framework fit accuracy is measured in many studies by the use of silicone replica measurement and those studies reported smaller gaps in the conventionally fabricated framework which means better fit accuracy compared with digitally fabricated RPD, but the aim of the study was to evaluate the selective laser sintering not the scanning technique [22]. In addition, the silicone replica method has several disadvantages, as it is difficult to handle the thin silicone material which can be easily distorted upon removal from the tooth surface or during its fixation under the microscope for evaluation. The thickness measurements of those replica are made on specific areas but none of these areas represent the overall framework fit [13].

Other methods for the assessment of RPD framework fit accuracy is the use of 3D analysis software which proved to be accurate and valid [23], [24]. Most of the studies used this 3D analysis methods are in vitro and they reported that the digital technology has more fit accuracy than the conventional one. However, those studies evaluated the technology not the scanning technique. [5, 12].

There are several other methods available to evaluate framework fit accuracy in the literature, one of them is the intraoral clinical physical visual inspection [4] that is used in the presented study. This method is considered to be a subjective qualitative method which considered to be less accurate in recognizing small misfits or gaps. However, in this method, a calibrated experienced blinded clinician with a high level of inter and intra-examiner reliability is responsible for the reporting of the results and this clinician has enough experience to evaluate whether a framework is clinically acceptable or not, and it represents the overall framework fit [13]. In addition, evaluation of clinical fitness and accuracy of RPDs, particularly the quantitative evaluation, is difficult because of the complexity of

the structures, the variety of components, and the wide range of designs. In addition, no commonly accepted guidelines exist for RPD frameworks evaluation. Therefore, a visual inspection and a pressing test for clinical fitness evaluation of RPDs, is an clinically accepted method and was used previously in the literature [9, 14, 25].

In the presented study the lost wax technique was used in the both group for framework fabrication in order to test the efficiency of the intraoral scanning per se and the intraoral scanning showed more accurate results. An in vitro study carried out on the effect of digital impression technique on the degree of adaptation of rests revealed clinically acceptable results in terms of the degree of adaptation of the rests, and lower mean gaps between the rest and its respective seat [19].

Clinically, the visual inspection of all frameworks in the presented trial showed accepted clinical fit and adaptation in both groups, and not only in the rest area but also throughout the entire framework. In addition, all frameworks showed high patient satisfaction. Two studies in the literature compared the conventional and digital methods reported that the type of impression did not affect the adaptation of rests [12, 19]. However, fabrication method whether its lost wax technique or selective laser melting (SLM) or direct milling of CO-CR, did affect the fit accuracy resulting in more accurate results in the digital groups [5, 12].

In a systematic review which analyzed fit accuracy of removable partial denture frameworks fabricated with CAD/CAM, rapid prototyping, and conventional techniques, it concluded that, the digital methods has more clinically acceptable fit, superior precision, and better accuracy than the conventional methods [4]. Therefore it can be concluded that the fabrication method itself plays an important role. However, the use of intraoral scanning as an alternative to the conventional impression can be more time saving, convenient and more satisfactory for the patients.

More clinical trials are recommended to evaluate the different types of intraoral scanners, scanning time, and the head size of the scanners in partially edentulous patients

CONCLUSION

Within the limitation of this study it can be concluded that, intraoral scanning can be a simpler and useful technique in partially edentulous cases.

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