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Accuracy of the Provisional Prosthesis Scanning Techniqueversus a Conventional Impression Technique on Completely Edentulous Arches

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Abstract: Purpose: In this study, we aimed to compare the marginal fit of fixed dental restorations fabricated with the provisional prosthesis scanning technique versus a conventional impression technique and to determine the effect of both variables on the accuracy outcome. Materials and Methods: Twelve identical polyurethane edentulous maxillary models were equally divided into two groups: control (conventional impression group) and test (provisional prosthesis scanning group). After obtaining the impression using the above-mentioned methods and further preparing the final prosthesis, the passivity of the metal framework prosthesis was checked using a single screw test, i.e., only one screw was fixed on the terminal right abutment, and all others were empty. The marginal fit of the final prosthetic frameworks screwed onto the implants on the terminal left abutment was measured at the terminal right sight by periapical radiographs obtained immediately after metal framework placements in both groups. The medians derived from the two groups were compared using the Mann–Whitney test. In all tests, a p-value < 0.05 indicated statistical significance. Results: In the provisional prosthesis scanning group, the median marginal fit discrepancy was 170 µm (range 120–190). In the conventional impression group, the median marginal fit discrepancy was 1080 µm (range 1040–1100). There was a significant difference in the implant-framework marginal gap fit discrepancy between these two groups. Conclusion: Prostheses fabricated with the provisional prosthesis scanning technique are significantly more accurate than those fabricated with conventional impression techniques.

Keywords: accuracy of implant prosthesis; provisional prosthesis scanning; conventional implant impressions; edentulous arch

1. Introduction

In implant dentistry, passive fitting of an implant-supported fixed prosthesis is essential to ensure correct and successful oral rehabilitation, especially in cases of immediate placement and implant loading [1–3]. There are several clinical and laboratory variables that affect the accuracy of an implant cast [3], but the most significant factor is the impression procedure. Heckmann et al. [4] reported that 50% of errors in terms of accuracy are because of the impression technique performed by the clinicians, while the remaining 50% are related to inaccurate laboratory procedures. The development of CAD/CAM systemshas resulted in new and more accurate methods that have replacedconventional techniques, particularly in implant prosthetic dentistry. In the digital workflow for full-arch fixed screw-retained restoration, final restorations can be fabricated by correlation techniques [5–9]. Several studies have recommended the advantage of digital impression methods as compared with conventional methods [4,10–12], however, there are relatively few studies reporting on the precision of final prostheses fabricated by digital workflow in edentulous patients.

The marginal fit of a final prosthesis is one of the most important factors for quality assessment of successful prosthetic treatment [11–15]. Numerous studies have evaluated the value of passive fit using multiple methods to demonstrate the importance of this point [16–18]. A misfit at the implant-abutment junction results in complications, including screw loosening/fracture, ceramic veneer fracture/wear/chipping, and crestal bone loss [2,19–29]. Hence, attempts should be made to ensure that an accurate master cast is produced to generate an accurately fitting implant-supported fixed final prosthesis.

The role of an implant and final prosthesis interconnection on the accuracy of implant casts generated with provisional prosthesis scanning technique for edentulous jaws has still not been fully investigated. Thus, additional studies are necessary to evaluate the accuracy of this method as compared with those of conventional techniques.

In this study, we aimed to compare the accuracy of full-arch prosthesis frameworks fabricated with the provisional prosthesis scanning versus a conventional impression technique, in completely edentulous cases. The null hypothesis was that the provisional prosthesis scanning technique would provide more accurate frameworks than the conventional impression technique.

2. Materials and Methods

2.1. Conventional Impression Group

Here, we used a polyurethane edentulous maxillary model with a soft tissue replica. Nine implants (UFII, DIO Inc., Atlanta, GA, USA) were placed in the canine, first premolar, second premolar, first molar, second molar, and right upper incisor, thereby creating a master model representing an edentulous maxilla with nine implants (Figure 1). The pick-up impression was obtained after connecting impression copings (DIO Inc.) to each of the nine implants (Figures 2 and 3). After obtaining the impression, implant analogs (DIO Inc.) were connected to the copings and a dental model was made by pouring stone (GC FUJIROCK, Tokyo, Japan) (Figure 4). Subsequently, digital impressions were obtained using an intraoral scanner (TRIOS, 3Shape, Copenhagen, Denmark) (Figure 5). A metal framework was designed using the digital impressions (Dental System, 3ShapeA/S, Copenhagen, Denmark) (Figure 6). The designed framework was fabricated with a CAD/CAM milling machine (Arum 5x-200, Doowon, Daejeon, Republic of Korea). This process was repeated six times to produce six titanium frameworks. The fabricated frameworks were placed on the model. Periapical radiographs (BEMEMS, Seoul, South Korea) were used to evaluate framework fit.

Figure 1. Placed implants with multiple abutments.

Figure 2. Connected impression copings.

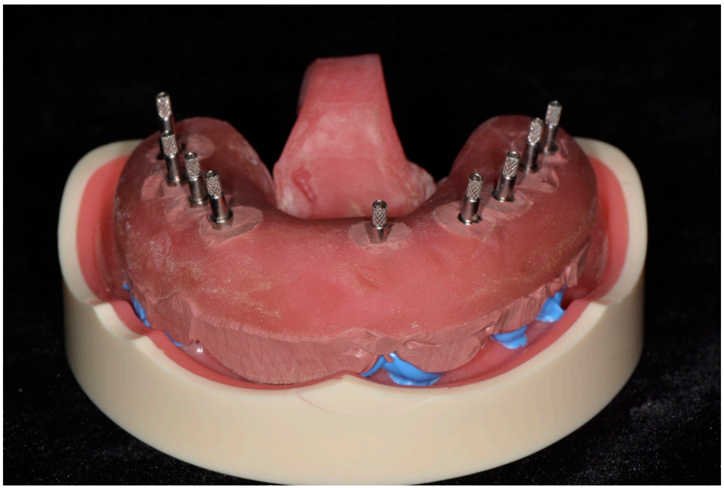

Figure 3. Obtaining the pick-up impression.

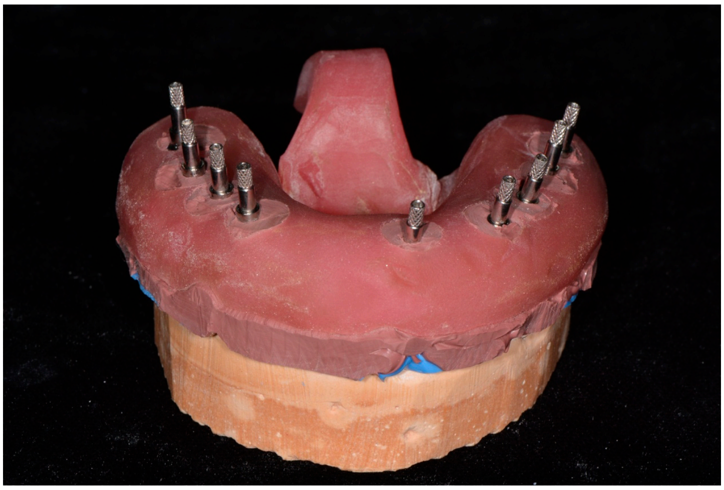

Figure 4. Creation of a stone model using implant analogs attached to copings.

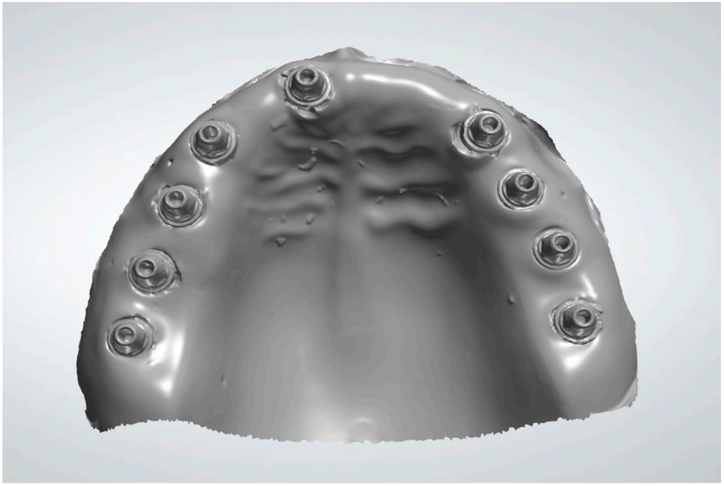

Figure 5. Scan image of the stone cast.

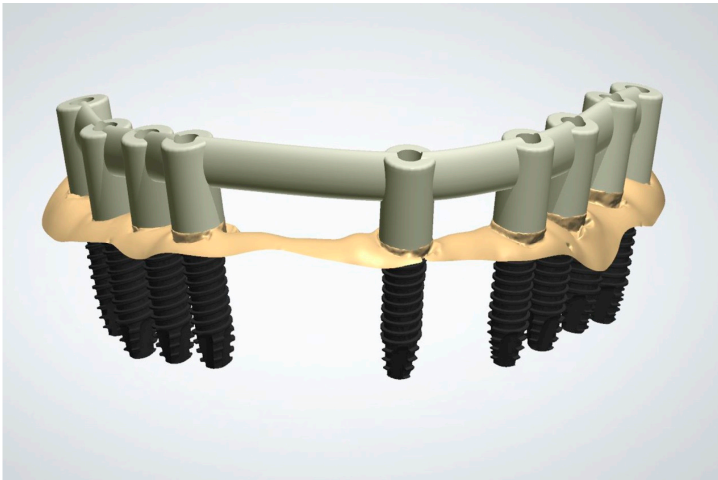

Figure 6. Designed metal framework.

2.2. Provisional Prosthesis Scanning Group

An identical polyurethane edentulous maxillary model with a soft tissue replica and nine implants was used for each model. The cylinders were connected to the implant (Figure 7). The rubber dam was placed beneath these cylinders (DIO Inc.) (Figure 8), and a provisional prosthesis, with cylinder access holes that were designed using IO scan data and CBCT scan data, was bonded with cylinders by injecting a composite luting cement (VERICOM CO., Anyang, South Korea) (Figure 9). After filling the provisional prosthesis access holes, the denture was removed with preliminary bonded cylinders to complete this process more precisely. Some laboratory tools (DIO Inc.) (Figure 10) were used to protect the base of the cylinders during the polishing process and to keep screw access holes open to easily fill the empty spaces between the cylinder and denture by injecting acryl resin (composite luting cement). The placed provisional prosthesis was scanned (TRIOS, 3Shape A/S, Copenhagen, Denmark), exported as standard tessellation language files, and saved. Once the virtual model of the jaws was created with the dental implant in position, a virtual digital framework was designed using CAD software (Dental System, 3ShapeA/S, Copenhagen, Denmark) (Figure 5). The designed final metal framework was fabricated (Arum 5x-200, Doowon, Daejeon, Republic of Korea) and positioned. This process was repeated six times to produce six titanium frameworks.

Figure 7. Cylinders connected to the multiple abutments of the implant.

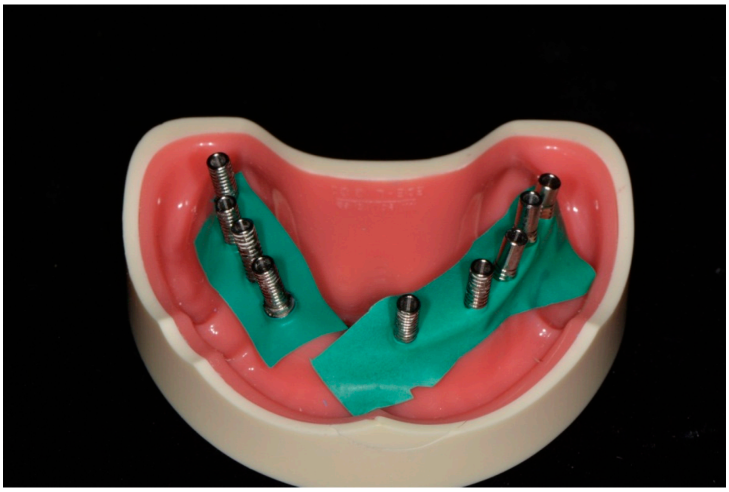

Figure 8. Rubber dam placed beneath the cylinders.

Figure 9. Provisional prosthesis with cylinder access holes.

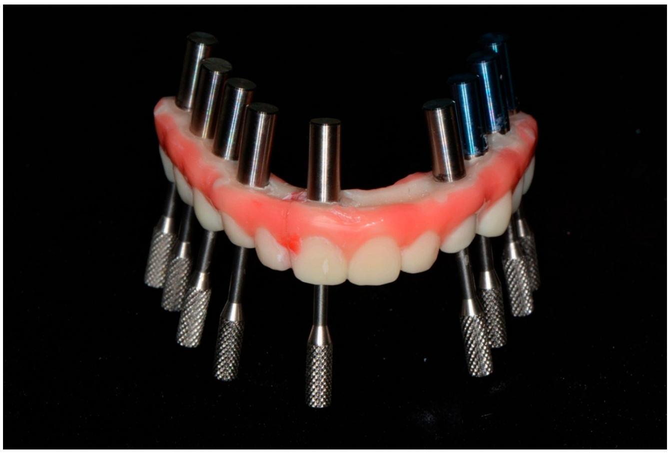

Figure 10. Laboratory tools that facilitate the bonding process to keep the cylinder access holes open.

2.3. Examination

The fit of the full-arch frameworks was tested on the master model using a single screw test (SST), i.e., only one screw was fixed on the last right abutment, and all others were empty. The marginal fit of the final prosthetic frameworks screwed onto the implants was checked on the last left abutment by periapical radiographs obtained after metal framework placement in both groups. All periapical radiographies were standardized, i.e., performing by the same surgeon, with the same radiographic machine and angulation (90°, perpendicular to implant axis). The gap between the implant's abutment and base of prosthetic framework was measured in "µm".

The medians derived from the models (two groups) were compared using the Mann–Whitney test. In all tests, a p-value < 0.05 indicated statistical significance.

3. Results

A total of 12 identical polyurethane edentulous maxillary models with a soft tissue replica were used, and 12 metal frameworks were manufactured using six models for each group.

In the provisional prosthesis scanning group, the median marginal fit discrepancy was 170 µm (range, 120–190). In the conventional impression group, the mean marginal fit discrepancy was 1080 µm (range, 1040–1100). There was a significant difference in the implant-framework marginal fit discrepancy between the two groups (Table 1).

Table 1. Marginal fit discrepancy between the conventional impression group (CIG) and provisional prosthesis scanning group (PPSG).

	CIG Mean ± SM	PPSG Mean ± SM	Mann–Whitney Test
Marginal fit discrepancy (µm)	170 ± 50	1080 ± 40	$p < 0.05$

4. Discussion

In this study, we aimed to compare the marginal fit of fixed dental restorations fabricated with the provisional prosthesis scanning technique versus a conventional impression technique and to determine the effect of both variables on the accuracy outcome. Achieving passive fit of implant prosthesis is a key factor in the long-term success of treatment [3,19]. Our study showed that the fit of metal frameworks fabricated with the provisional prosthesis scanning technique was significantly more accurate than those fabricated with the conventional impression open-tray technique. The results of a few previous studies have demonstrated superior accuracy, in terms of trueness and precision of fully digital impressions for full-arch restorations as compared with those of conventional techniques [30–35].

Our results are in agreement with those by Jokstad et al. [36] who reported that the mean vertical fit discrepancy of a prosthesis with a fully digital workflow was 169 µm.

Clinical studies have reported that an acceptable fit discrepancy is within the range from 100 to 200 µm [16,37,38]. According to Jokstad et al. [36], a fit discrepancy < 200 µm was considered to be clinically acceptable. The results of the present study lie within these ranges for the provisional prosthesis scanning group, while those of the conventional impression group lie outside the reported ranges of the acceptable misfit. The above-mentioned findings highlight the potential advantages of the so-called complete digital workflow.

Impression accuracy and the fit of the definitive prosthesis depend on the phases of the process. Various factors can contribute to a misfit of the final prosthesis, such as the accuracy of implant impression, master cast fabrication, and prosthesis fabrication procedures [39].In conventional techniques, each step (connection of impression copings, obtaining impression, connection of implant analogs, mechanical tolerance in each step, creating a stone cast, scanning, merging process, designing, and milling) has its own errors, and accumulating all of these has a significant effect on the accuracy of the final fit [2,3,19–29,39–41]. In contrast, the provisional prosthesis scanning technique requires fewer steps (i.e., creating provisional prosthesis, scanning, designing, and milling); consequently, the number of error sources is fewer as compared with the conventional techniques [3,40,41]. This can explain the significant marginal fit discrepancy between these two methods in our study. Understanding the impact of these factors helps to ensure the fabrication of an accurate master cast, which reduces the risk of framework misfit.

Using fully digital workflow minimizes complications associated with framework misfit. In the present study, a relatively high variation of precision in the provisional prosthesis scanning group can be caused by cylinder displacement. One of the common reasons is cylinder damage which can occur during the prosthesis polishing process. To eliminate its effect on the final prosthesis accuracy, the cylinder base should be protected using polishing caps during the polishing process. Another key factor that hinders the full sitting of cylinders is an ill-fitting prosthesis screw access hole with cylinders connected to the implant during the bonding process. In this case, the final accuracy depends on the skills of the surgeon and their precision in applying adequate mechanical power and fixing/bonding in the correct angle, which plays a key role in achieving a satisfactory final result. The next important aspect, which depends on the skills/methods of the surgeon, is the scanning process, in which the surgeon scanning technique is considered to be more crucial than the influence of various intraoral scanners on the accuracy of the results [42].

To assess the effect of misfit in clinical studies, most authors have attempted to measure the gap between the framework and abutments. The importance of a vertical fit has been emphasized in several studies [43–45]. However, there is still no standard protocol to assess the fit of dental restorations [46].There are several methods for assessing the fit of screw-retained implant prostheses that have been used by others [47–52]; however, SST continues to be a simple and popular method to use both clinically and in dental laboratories [16,26].Moreover, this method is considered to be highly informative for the estimation of workflow accuracy despite its ordinariness. Thus, in the present study, qualitative assessment of the vertical microgap was performed with SST.

The findings of the current study can be beneficial in the clinical setting for both surgeons and patients. First, less time is required for the whole process with a reduction in the preparation efforts by the surgeon (total, 9 h; designing, 3 h; milling, 5.5 h; and finishing in patient mouth, 0.5 h) and there is a decrease in the number of patient visits.

The provisional prosthesis scanning technique is a relatively new method involving a fully digital workflow. To the best of our knowledge, there have been no published studies on the role of the provisional prosthesis scanning method in improving the accuracy of full-arch implant prosthesis on the edentulous ridge. This limits the comparison of current findings with the results of other studies. Nevertheless, the results of the present study for the provisional prosthesis scanning group lie within the clinically acceptable range, and the findings were derived from a model experiment. Further clinical studies are required to confirm these outcomes in the clinical sphere.

5. Conclusions

In general, our findings suggest that prostheses fabricated with the provisional prosthesis scanning technique are significantly more accurate than those fabricated with conventional impression techniques. Nevertheless, a model experiment does not always produce predictable and possible uncontrolled cause and effect out comes in natural conditions. Hence, further in vivo investigations are required to determine whether the results of this study are consistent with clinical findings.

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