Journal of Applied Cosmetology

ISSN 2974-6140 (online) ISSN 0392-8543 (print)

Review

Could digital workflow replace the conventional? A narrative review

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Keywords: *workflow, prosthodontics, computer-aided design, dentistry, dental implants*

Received: 20 July 2022
Accepted: 9th November 2022

ISSN 2974-6140 (online) ISSN 0392-8543 (print).

ABSTRACT

In the last ten years, digital technologies have conditioned our lives in many ways. Also, in dentistry, new inventions changed our working routine, accompanying the clinician from the analogic epoch to the digital. A fully digital workflow seems to be very promising in terms of less discomfort for the patients and less time needed to make an impression than the traditional method. However, many aspects still need to be investigated, such as the procedure's complexity, the optical impression's reliability, the precision of the CAD-CAM-made crown, the costs, and the time needed to deliver a final crown. This review aims to understand, analyzing some RCT studies, whether a digital workflow is reliable compared to the analogic.

INTRODUCTION

In the last years, digital Technologies have become part of our lives to the point of conditioning the timing and how we communicate with each other. Nowadays, it would be unthinkable to work without any electronic device, whether a computer, a smartphone, or a tablet, since such devices allow us to store and share a significant amount of fundamental data for our activities.

In dentistry, digital progress has been principally developed in CAD/CAM systems and imaging systems. Computer-aided design (CAD) systems and computer-aided manufacturing systems were initially developed in 1950 by the American Air Force to design automotive and aeroplane components. After three decades, this technology was also applied to dentistry when Francois Duret developed the first CAD/CAM dentistry device, which was substantially made by an optical device for the impression and a numerically controlled milling machine (1).

Werner Mormann developed the CEREC System, the first commercially available chairside CAD/CAM system for dentistry, and it allowed delivery of a fixed final crown in a few hours (2). The first chairside treatment made with CEREC was executed in 1985 at the Zurich Dental School and the fact that this system allowed the clinician to deliver a fixed final ceramic crown the same day as the impression was revolutionary (3-7).

Nowadays, the CEREC system is largely used worldwide, and with the progress of technology, it has become a predictable and accessible workflow system. The evolution of dentistry digital imaging started with the invention of CBCT (8) and culminated 10 years ago with the invention of optical scanners.

The intraoral optical scanners allow the clinician to take a direct impression by projecting a light source onto the teeth and soft tissues of the mouth (9, 10). The image is captured by high-resolution cameras and processed by powerful software that produces a 3D digital model (11, 12). It allows the clinician to avoid the traditional plaster models and to have, in a few minutes, a digital model that replicates dentogingival tissues (13, 14).

There are many different types of optical impressions systems; the most common ones on the market are Trios 3, 4, 5(3Shape), iTERO Element 2, iTERO 5d Element (Align Technology), CS3800 (Carestream), Panda P2 (Pengtum technologies), Medit i700 (Medit Corporation), Planmeca Emerald S (Planmeca), Cerec Omnicam (Dentsply Sirona).

Each scanner has specific characteristics; comparative studies comparing different scanners have been performed, such as the one performed by Pokpong Amornvit, Dinesh Rokaya and Sasiwimol Sanohkan: "Comparison of Accuracy of Current Ten Intraoral Scanners" (15). In this study, a maxilla model was scanned with different scanners and measurements were taken on the respective STL files in the X, Y, Z and XY axes.

According to the study, the greater the distance the scanner travels, the lower the accuracy and the greater the error. The precision in this study appears similar for all the scanners analyzed, while the trueness value varies, showing that Trios 3 and 4 from 3Shape reported better results than the others in both categories.

Other studies comparing the various optical impression systems include, for example, Miran Kwon and Coll's "Full-arch accuracy of five intraoral scanners: In vivo analysis of trueness and precision" (16) from which, comparing trueness and precision values, concludes that in the two categories the one that seems to perform better still turns out to be Trios 3.

The analysis conducted by Walter Renne, "Evaluation of the accuracy of 7 digital scanners: An *in vitro* analysis based on 3-dimensional comparisons" (17), shows that regarding trueness values for the full-arch, the best performance was recorded by D800 (3Shape), followed by iTero (Align Technology), TRIOS 3 (3Shape), followed by the others.

Regarding Precision values in full-arch scanning, the best scanner was CS3500 (Carestream), then iTero (Align Technology), then TRIOS3 (3Shape) and then all others. On the other hand, the most accurate and truthful scanner for posterior sextant scanning was the CS3500 (Carestream), while for full-arch scan, TRIOS3 (3Shape) offers the best compromise between scanning speed and accuracy.

The traditional impression technique could sometimes be very uncomfortable for patients, especially those with strong gag reflexes (18-20). On the contrary, the optical impression is well tolerated by the patients, and sometimes it could also be easier for the clinician (18, 21, 22). Once the 3D model is obtained, it can be used by the technician to project and model a prosthesis, a provisional and final crown or bridge, a Toronto bridge, a bite, a surgical or radiological guide and so on.

One of the most widely used software is Exocad's Dental Cad software, which allows for most designs, from custom abutments, screw-retained bridges, simple and complex bars, monolithic zirconia crowns, metal copings, esthetic veneers and more (23). When the technician completes the projecting phases, the STL file can be sent to a CAM milling machine or a 3D printer to obtain the final physical product.

A fully digital workflow seems advantageous for patients and clinicians, but it is a relatively new way of working, and we are still trying to understand the limits of this technique. Therefore, this review aims to investigate those aspects that could be critics in making a prosthetic rehabilitation using a fully digital workflow compared to the traditional, analyzing data from four specific articles in which these protocols had been examined.

The secondary aim is to provide unbiased information about a new digital way of working, analyzing features such as operative times, prosthetic success rate, costs, patient satisfaction and more.

An overview of the advantages and disadvantages of both traditional and digital workflow will be provided, helping the reader understand the clinical situations in which a digital workflow can be used successfully. This article wants to analyze the available data about these technologies impartially, obtaining some clear indications about their use in clinical practice.

Design of the review

The digital workflow is a current argument in research, one of the first articles about digital workflow making CAD-CAM references was written by Dennis J Fasbinder in 2010 (24). In the last twelve years, reviews have been written to clarify this new workflow's positive and negative aspects, sometimes showing discordant outcomes.

This paper aims to indagate the argument by analyzing data of RCT studies and trying to track a common line to shed light on the present and future of restorative and prosthodontic dentistry.

For this review, PubMed research has been conducted using the keywords “digital” AND “crown” and selecting RCT as an option. The research produced 100 articles which were reduced to 20 after selecting “full-text”. Articles published before 2015 were excluded from this review to obtain updated data about the topic.

Only articles with a good level of evidence were selected. Four articles were chosen from the twenty after reading the abstract, following homogeneity criteria. The selected articles strictly dealt with the topic and provided valuable data in accordance with the aims of this study.

We opted to do a narrative review, analyzing aspects that could be more critical for clinicians and patients. The most important findings of the articles selected for the present study were analyzed and reported in the review. The focus of this review is to answer simple questions that clinicians could ask before approaching these new techniques:

- Is the digital workflow equally efficient compared to the analogic one?
- Does the digital workflow have fewer working and crafting prothesis times than the analogic workflow?
- How do the patients perceive the optical impression compared to the traditional one?
- What kind of technique do the clinicians and technicians prefer?
- Is the quality of the prosthesis comparable?
- Does the cost of the prosthesis decrease for the clinician using a digital workflow?
- Are there more complications using a digital workflow compared to the analogic workflow?

RESULTS

First article

To answer these questions, we analyzed four articles: the first one was written in 2018 by Francesco Mangano: “Digital versus Analog Procedures for the Prosthetic Restoration of Single Implants: A Randomized Controlled Trial with 1 Year of Follow-Up” (25).

This RCT study compares a digital workflow to an analogic workflow in single implant restoration. The population was made of 50 patients, 22 male and 28 female, with an average age of 52, divided with randomization into two groups of 25, the test and control groups. Both groups were treated with single-implant prosthetic crowns. The test group was treated with a monolithic zirconia crown following a digital workflow; the control group was treated with a single ceramic-steel crown following the analogic workflow instead.

After a one-year follow-up, no patient dropped out of the study, and the success rate was 92% for both groups. The test group recorded a percentage of biological and prosthetic complications of 4%, while the control group had 8% of biological complications but no prosthetic complications. Both groups showed a prosthetic success rate of 92% without any statistically significant difference between them. Also, in the case of marginal bone loss, no differences between the groups were recorded, with a total value of 0.47 ± 0.31 mm.

Patient satisfaction was evaluated with a VAS scale, and during the impression procedure, patients considered the optical impression more comfortable than the traditional one, with fewer gagging and nausea episodes. However, no differences were observed in comfort during the restoration phase.

The digital workflow received a higher rating in treatment times (average difference in VAS:+16,$p < 0.0001$) and costs (+9.2, $p = 0.01$). For the esthetic results, there were no differences between the two groups. However, the VAS total score showed a statistically significant difference in favour of digital workflow (+ 9.9, $p < 0.0001$).

To take an optical impression requires less time than the analogic one made with the double impression technique, which requires more than double the time (20 ± 5min versus 50 ± 7min; $p < 0.0001$). When calculating the active working time for the dental technician, the workflow in the test group was more efficient than that of the control group for both the provisional (70 ± 15 min versus 340 ± 37 min; $p < 0.0001$) and the final crown (29 ± 9 min versus 260 ± 26 min; $p < 0.0001$). There were no differences in the delivery times.

The realization cost of a final zirconia crown with a digital workflow was Euro 277.3, whereas a ceramic-steel final crown made with a traditional analogic workflow was Euro 392.2.

In analyzing this article, a digital workflow seems to be more advantageous in terms of comfort for the patient, working times and costs. Regarding impression times, such a big difference between the two groups could be due to the double impression technique used for the control group. This data contrasts with other works, and using a different technique, such as a polyether mono-impression, could significantly reduce the traditional impression times.

Second article

The title of the second article analyzed was "Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures.

Part I: Time efficiency of complete-arch digital scans versus conventional impressions": it included a small population of 10 patients needing a posterior tooth-supported 3-unit FPD (26). The clinical treatments were performed by 3 calibrated clinicians (I.S., G.B., S.M.) experienced with digital scanners and ceramic CAD-CAM prostheses. For each patient, the clinicians used three digital scanners (iTero, Cerec and Lava) and one conventional impression.

The results showed that the full-arch conventional impression took less time than the intraoral scanner. The difference was statistically significant for two of the three scanners, iTero and Cerec; moreover, using Cerec took more time than the other two systems. The scanning had to be repeated three times with the Lava scanner and seven times with iTero, while the conventional impression was only made once.

When the VAS value was assessed, the patients and the clinician evaluated the digital scanner less comfortably than the conventional impression; in particular, they found scanners that required powder during the procedure more complex than the others. However, the patients generally did not express any preference between the different impression methods.

The clinician preferred traditional impressions to digital ones and impressions without using powder to the ones with powder. In this study, data regarding the timing of the procedures are opposite to the results of the first study.

Third article

The third article examined is an RCT (27) which analyzes the prosthetic implant restoration of single implant tissue level Straumann RN, comparing the optical impression to the analogical one, using polyether. Again, 32 patients underwent rehabilitation, and a total of 32 implants were used: 23 for the test group and 22 for the control group.

Twenty-one patients received a single crown, 9 patients two crowns and 2 patients 3 crowns. In 9 of the 23 patients in the test group (39.1%) and 2 of the 22 patients in the control group (18.2%), fitting was adequate and did not require modifications. Fourteen crowns in the test group and 18 in the control group required modifications before being placed in the mouth. The time used by the clinician to modify the crown went from 3 to 11 minutes (mean = 3.35 min) in the test group and from 2 to 18 minutes (mean = 6,09 min) in the control group.

During the first year of loading, two complications occurred to the same implant in the control group. In the test group, one biological complication developed after three months of loading, leading to implant mobility with no signs of inflammation.

The results of this study show that a try-in of a CAD-CAM solitary screw-retained monolithic zirconia implant restoration needs shorter adjustment times than the conventional for the same restoration type and exhibit low complication rates and higher survival rate on the short-term (one-year follow-up).

Fourth article

The fourth study reviewed is an RCT titled “Digital vs conventional workflow for one-abutment one-time immediate restoration in the esthetic zone: a randomized controlled trial” (28). The article analyzes the short-term outcomes of single implants in esthetic areas in 18 patients, using the technique “one abutment, one time” and comparing a conventional workflow (analogical) to a fully digital workflow.

In the study, the impressions were made using alginate and 3Shape (TRIOS®, Denmark) for each patient; then the patients got CBCT scan, and the STL files from the digital impression were imported and merged in DicoDiagnostiX® software. The implant positioning was planned using this software.

The test group used the CARES software to do a digital tooth setup. The setup was combined with the initial planning, modifying the position of the implant to have a prosthetic-favourable final position. A fully guided drill guide was ordered at the end of the planning phase. The technician, guided by the previous planning, created a custom-made zirconia abutment and a provisional prosthesis in PMMA CAD-CAM, which were then used on the day of the surgery. Moreover, the technician built a silicon verification key on the surgical guide’s buccal side so it was possible to verify the implant position during its placement.

In the control group, orthocryl free-hand surgical guides based on a conventional wax-up were performed, and the technicians created an individual impression tray. During surgery, the consecutive drills of the implantation procedure were carried through the free-hand guide to position the implant according to the prosthodontic planning. A precision impression was then taken using the individual impression tray immediately after the implant insertion. Using the impression taken after the surgery, the technician planned a final zirconia abutment using the diagnostic wax-up. Following this phase, a PMMA-stratified provisional crown was produced.

Surgical results

In the control group, the insertion of the conventional guide was possible for every patient with no modifications; in the test group, the surgical guide needed modifications in order to be fitted. The higher deviation in the entrance site was 1.13 mm in the test group’s surgical guide, which was modified later. In one case, the clinician had to change the height of the implant due to a standard deviation of 2mm in the vertical dimension.

The global apical deviation (GAD) was significantly higher in the control group compared to the test group ($p = 0.014$). In addition, significant differences were observed for the Angular deviation ($p = 0.014$) and the Apical vestibular deviation ($p = 0.038$) in favor of the fully guided surgery.

No significant differences were registered regarding the Coronal global deviation, Coronal distal deviation, Coronal vestibular deviation, Coronal apical deviation, Apical distal deviation, and Apical deviation.

All the implants obtained primary stability, a 15Nm torque was used for all the custom-made zirconia abutments, and all the provisional prostheses were inserted right after the surgery in the test group and after 10 days in the control group. There were no statistically significant differences between the two groups concerning occlusion and interproximal contacts; the two groups both required occlusal modifications in almost half of the patients.

The White Esthetic Score (WES) showed no significant difference between the two groups, even though the scoring was not higher in the group with the conventional stratified provisional crown. However, the PES score tended to be higher in the test group. In terms of soft tissue colour and texture, the values of “2” were recorded for all patients in the test group, while the proportion of score “2” was 44.4% in the control group (p = 0.029, respectively).

The satisfaction scores were similar between the groups, except for the comfort during the polyether impression (control group) vs digital impression (test group); the digital impression was found to be significantly more comfortable compared to the conventional one (p = 0.014). No statistical differences were registered in the esthetic VAS in the two groups. Both methods showed the authors registered satisfactory results and no statistically significant differences in the outcome regarding esthetics. The patients preferred the optical impression to the conventional polyether one, as the previous one caused less discomfort.

DISCUSSION

In the past two decades, dentistry has made great strides in evolution in both techniques and materials (29-48), nowadays increasing number of clinicians use the optical impression in their office, choosing the digital workflow for many reasons. From these studies, we deduce that in terms of aesthetics and reliability of the final crown, there are no differences between digital and analogic workflow, which also concerns the need for occlusal and interproximal modification in the delivery appointment.

There were no differences between the two groups in the post-delivery prosthetic complications. For what concerns the times needed for the impression, there is a certain discrepancy of data and, in our opinion, it depends a lot on the conventional impression technique used for the comparison; however, it seems to be easier to take the impression using a scanner without the necessity of the powder.

A fully digital workflow seems to be more efficient for the realization of the final crown, showing shorter times in the crafting process. The costs of a final crown made using a fully digital workflow seem less expensive for the clinician compared to the analogic.

The patient, except for the second article, appears to prefer the optical impression compared to the traditional one, mainly because of a less gagging and nausea episodes, whereas there are still contrasting opinions among the clinicians, and it might depend on the dexterity in using the new technique.

These data agreed with recently published systematic reviews such as “3D Digital Impression Systems Compared with Traditional Techniques in Dentistry: A Recent Data Systematic Review” by Marco Cicciù et al. (49), in which, in addition to what has already been said, there is evidence of greater ease of use of the optical impression for students than for established professionals, this may be due to the unwillingness of those professionals, who have been used to working in a certain way for so long, to change.

Limitations

Since digital workflow was introduced in dentistry not years ago, only a few data about these new technologies are available in the literature. Moreover, the high cost of the equipment makes it even more challenging to design clinical studies that provide data with a high level of evidence.

Extended research that includes a larger number of reliable studies should be conducted in the future when more knowledge about these technologies will be acquired, and the use of the equipment will be extended in clinical practice.

This paper has not considered all the techniques that could be used for digital workflow; however, interesting recent reviews, such as that of Lavorgna et al. (50), does compare the values obtained with different optical impression systems and the photo-detection system on which Digital Smile Design is based.

CONCLUSIONS

The use of the optical impression undoubtedly required a learning curve to optimize times and avoid making the same impression many times. However, even with some critical points, such as powder use, the optical impression seems reliable and precise, especially for single or small implant-supported bridges.

From the analysis of these papers, we can conclude that, for what concerns fixed implant-supported prosthesis, a digital workflow showed promising results. However, the limits of these methods are the powder's use and the time needed to take an impression.

A digital workflow is a viable alternative to the traditional workflow; it seems to work better for some treatments than others. However, there is still a conflicting opinion in the literature and among clinicians about its applicability and benefits in daily clinical practice.

It will undoubtedly be interesting to carry out new research in the future, also trying to create large databases to enter all the various digital data collection systems and compare them with each other in order to highlight the strengths and weaknesses of each.

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