

Model-less digital workflow for the replication of an existing complete fixed implant-supported prosthesis using an intraoral scanner

Roberto A. Markarian¹  | Marco Feitosa Filho¹ | Ednaria Vasconcelos²

¹Private Practice, São Paulo, Brazil

²Universidade Nove de Julho, São Paulo, Brazil

Correspondence

Roberto A. Markarian, Implart Dental Clinic, São Paulo, SP, Brazil.
Email: roberto@implart.com.br

Key Clinical Message

The use of an intraoral scanner was efficient to produce a full-contour zirconia CAFIP, with improved esthetics when compared to the original prosthesis.

KEYWORDS

CAD/CAM, dental implant, digital workflow, monolithic zirconia, zirconium oxide

1 | INTRODUCTION

The successful delivery of complete-arch fixed implant-supported prostheses (CAFIPs) includes precise treatment steps regarding planning, implant placement, clinical, and laboratory procedures.¹ The clinical prosthetic workflow for CAFIPs requires the recording of implant tridimensional positions, along with soft and hard tissue contours. Also, prosthetic gingiva volumes and ideal teeth positions need to be transported from initial try-ins to the final prosthesis to achieve fully functional and esthetic results.²

Due to the efficiency and the cost-effectiveness, CAD/CAM systems have driven the increased development of such technologies for CAFIPs.^{3,4} One of the useful software tools available in dental scanners is a dual-scan protocol in which the gypsum cast containing the implants can be superimposed with a prosthetic reference, facilitating the design of the final structure for CAFIPs.^{5,6} This strategy was used in by Paspaspyridakos et al,⁷ which described an expedited protocol illustrating a digital workflow for full-arch implant rehabilitation of the extremely atrophic mandible in three appointments, using a scanned provisional prosthesis and the scanned working cast.⁷

Theoretically, an intraoral scanner could be used to collect all the required data to fabricate a CAFIP. By scanning directly intraorally, we could produce the restoration more

efficiently by reducing clinical and laboratory fabrication steps; avoiding inaccuracies that can occur from impression materials and gypsum deformation; requiring less intervention along the processes; and reducing the chance of human errors.⁸⁻¹⁰ However, there are few reports of full-arch intraoral scans for CAFIP fabrications, and one of the main reasons may be the difficulties related to record hard tissue data points in complete-arch cases, using intraoral scanners.^{11,12}

As digital software, hardware, and new materials keep developing, new workflow possibilities are emerging. Zirconium oxide (ZO) is one of the materials suited for implant-supported CAD/CAM rehabilitations, prepared via subtractive milling, as it offers good esthetics, biocompatibility, shade stability, low accumulation of plaque, good resistance to abrasion, and low thermal conductivity.^{13,14} Recent advances in the ZO technology were achieved by the production of variants with improved translucency that allows the construction of full-contour restorations, combining esthetic results along with high mechanical properties.¹⁵⁻¹⁷

In this clinical case report, a novel and completely digital workflow was used for the fabrication of a complex full-arch implant rehabilitation with minimally veneered monolithic zirconia, based on an existing prosthesis. For that end, the strategy included one intraoral scanner, besides CAD and CAM optimizations through a model-less approach.

2 | CASE REPORT

A 46-year-old woman presented with an edentulous maxilla and the intention to substitute her implant-supported metal-acrylic resin prosthesis for esthetic concerns and tooth wear. The prosthetic maxillary midline deviation detected was not a concern. The patient requested an expedited and efficient treatment with a 4-week deadline. Clinical and radiographic examination revealed six implants placed in the maxilla, two posterior zygomatic fixtures, and four anterior parallel implants with prosthetic abutments installed onto all of them (Figure 1). Mild mucositis was observed around the implants. The lower arch was fully dentated.

Mild horizontal bone loss was noticed, with no signs of acute periodontal disease. The vertical dimension and occlusal plane were considered preserved, and there was no TMJ symptomatology.

Different treatment plans were discussed between the dental team and the patient, who agreed to replace her metal-acrylic resin maxillary CAFIP, with a new full-contour zirconia. The patient only agreed with the periodontal treatment on the lower jaw, committing to subsequently proceed with all the needed treatments. The patient was not able to recover the implants brands and models, from the original implantologist. However, the prior prosthetic abutments were all considered in good conditions, and as such, they were kept to support the final rehabilitation.

Despite the signs of wear and aging, prosthetic contours, labial support, and vertical dimension were preserved, and for that reason, the replication of the information into the final rehabilitation was considered useful (Figures 2 and 3). The patient was informed that keeping a long buccal flange in the new prosthesis, such as the one present in the previous version, was not recommended for hygiene reasons; however, the patient did not agree to diminish the buccal volume for esthetics concerns with the labial support.

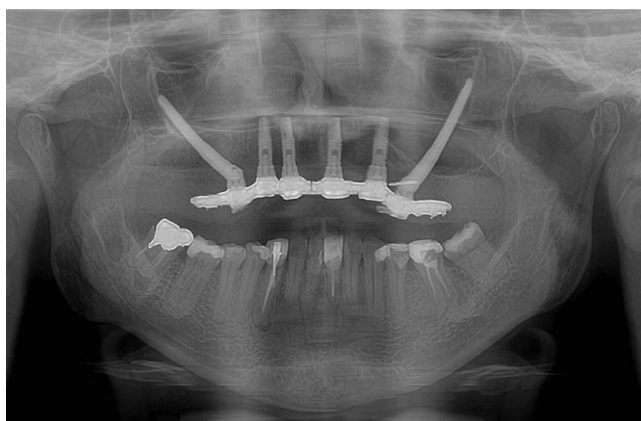


FIGURE 1 Panoramic X-ray showing the initial condition of the patient

One intraoral digital scanner (Trios 3; 3shape) was used for the digital impressions, including the original prosthesis as a reference in dual scan. The resulting scan file for both jaws with the correct occlusion was sent to a dental laboratory for virtual planning (Esteticart, São Paulo, Brazil). Using Dental System design software (3shape, Copenhagen, Denmark), one CAFIP was projected to match references of the original one (Figure 4). Some improvements were achieved in occlusal, palatal, and buccal teeth anatomy design. A cutback was done at the buccal side of the anterior teeth between canines and at the gingival region to allow ceramic layering and esthetic individualization. The prosthetic-abutment interface was designed with a cutback to include an interposed titanium-based (Ti-based) insertion.

The final restoration file was then exported as a STL file (stereolithography) and imported into a CAM software (Match 2; Amann Girrbach), in order to be milled in a machine (Ceramill Motion 2; Amann Girrbach, Koblach, Austria). Translucent zirconia was chosen as the material for the final restoration (Ceramill Zolid; Amann Girrbach). After milling, the material required some finishing refinements and was pigmented to enhance the final color scheme predicted



FIGURE 2 Extraoral initial condition of the treatment



FIGURE 3 Intraoral picture showing tooth wear and esthetic issues with the previous maxillary restoration



FIGURE 4 The new CAFIP was projected to match the references from the original one. This image shows both prostheses superimposed, while in CAD project

(Ceramill Liquid; Amann Girrbach), and then sintered in a dedicated furnace (In Fire; Sirona, Bensheim, Germany), according to the manufacturer's instructions. After the 12-hour sintering cycle, the structure was released from the rest of the blank and sent for a clinical trial, altogether with the Ti-based abutments (IMAC 04; SIN) that were fitting passively into the interface hollows.

As there was no working model, the final fit of structure could only be tried in mouth. After clinical try-in and radiographic analysis, fit was considered optimal, and minor occlusal adjustments were conducted at low speed. The structure was then sent to the laboratory for ceramic layering onto gingiva and between canines to achieve the desired contour and shade.

The patient and the dental team approved the finished prosthesis in esthetic and functional requirements. The structure interface hollows and the Ti-based abutments were then cleansed with ethanol. Composite resin cement (RelyX Unicem; 3M ESPE, Maplewood, MN, USA) was then applied to the surfaces of both devices, and the excess cement was carefully removed. The complete set was then installed in the patient's mouth with a 10 N cm fastening torque and prepolymerized with a light unit for 20 seconds at each implant screw site, while the patient was occluding. The CAFIP was removed from the patient's mouth for finishing, and the interface Ti-based abutments were polymerized from the base side for another 40 seconds. The CAFIP was finally secured in mouth with a 15 N cm. All screw accesses were sealed with PTFE pellets and composite resin (Z250; 3M ESPE) (Figures 6 and 7). A panoramic radiograph of the patient was made for post-treatment assessment (Figure 8).

The patient was instructed on proper oral hygiene techniques, to initially follow a soft diet and was scheduled for periodic follow-up appointments, up to 3 months after final installation.

The proposed treatment with a digital approach was efficient in the delivery of a full-contour zirconia CAFIP, with improved esthetics when compared to the original metal-acrylic resin implant-supported prosthesis.

The patient was then referred to an Endodontist, for further analysis of the periapical radiolucencies detected in teeth #22, #23, #27, and #31 that were asymptomatic.

3 | DISCUSSION

In the present clinical report, the use of an intraoral scanner, along with CAD/CAM software and equipment, enabled the dental team to plan and fabricate one zirconia CAFIP, through a model-less digital workflow.

In the presented patient report, despite the signs of aging, the patient did not request significant esthetic changes to the new rehabilitation (Figures 1-3). The rationale applied to the patient was that the replication of general prosthetic contours, vertical dimension, tooth disposition and size, gingiva volume, and color references could shorten the clinical steps and increase final predictiveness (Figure 4). As such, the volume of the previous CAFIP superimposed with hard and soft tissue contours, needed to be transported, by a dual-scan technique into the CAD software to enable the new design.^{4,5,17}

The correct use of an intraoral scanner was a key moment in the methodology, allowing the acquisition of all the data needed in one straightforward session: (a) implant tridimensional locations; (b) impression of gingiva contours; (c) prosthetic implant emergence profiles; (d) previous prosthesis gingival volume; (e) previous tooth shapes and tridimensional positions; (f) the occlusion as related to the previous prosthesis; (g) vertical dimension; and (h) opposing arch.

The scanned data gathered were used by the dental technician to establish correct design parameters for the final production of the structure. While in CAD, the design resembled those made from gypsum casts using a dual-scan strategy in laboratory scanners.

The material chosen for the final CAFIP was ZO, as it would allow a balance between translucency and structural resistance.¹⁵ A zirconia structure is often constructed to be veneered with ceramic. However, in order to prevent the problem of chipping of veneering porcelain, and improve resistance, monolithic full-contour zirconia has been proposed for CAFIPs. Recent studies have reported that ZO is a predictable material with good results up to a 5 year follow-up for the construction of either monolithic¹⁶ or layered CAFIPs.^{13,14}

In the presented patient, only a ± 1 mm space at the prosthetic buccal side of teeth and gingiva was left to be veneered with ceramics. The design and cutback of the structure in CAD were made to guide the manufacturing pathway, facilitating an esthetic effect of individualization of teeth and a

good fit to the crestal side (Figure 5). Veneering ceramics onto the structure without a working model proved to be a challenging task for the ceramic artist; however, the coloring of the structure during the sintering process, helped to achieve the desired colors. The result was an esthetically pleasant prosthesis, in which the layered ceramic was slightly more translucent than the raw zirconia regions (Figures 6 and 7). The patient also reported the new prosthesis to be more comfortable, because of the slimmer volumes on the gingival and palatal sides, the more detailed tooth anatomies, and the more pleasant overall texture for oral soft tissues, especially in the ceramic veneered regions. Additional modifications in shapes and colors were not needed after a trial insertion in this patient, but if necessary, a working model could be fabricated to that end, by 3D printing or by conventional implant impression methods.⁸

Dental CAD/CAM systems allow the prosthetic seating interface to be milled directly onto the prosthetic structure⁴ or by cementing on prefabricated titanium-based abutments.² The cement on strategy combines the strength and fit precision of a titanium dental implant-abutment interface with the esthetics of shaded custom-milled ZO and results in low wear to prosthetic abutments.¹⁸ An intraoral cementation of titanium interfaces was chosen in the present patient, as the cement could minimize some misfit, creating an accommodation layer between Ti-base and prosthesis.

In vitro studies suggest that intraoral scanners can be used for digital full-arch implant impressions, with acceptable precision and accuracy.^{6,9,12} Gherlone related good clinical results when constructing all-on-4 CAFIPs through an intraoral scanning workflow,⁸ and such results agree with the present case report as a passive fit was also noticed in the presented patient by clinical and radiographic analysis (Figure 8). From the previous background, we can infer that the fabrication of a CAFIPs from intraoral scans is challenging as the recording of hard tissue reference points in complete-arch cases is still not optimized in current intraoral scanners software and hardware.^{11,12}



FIGURE 5 Appearance of the zirconia CAFIP structure after pigmentation and sintering, before ceramic veneering



FIGURE 6 Extraoral final condition of the treatment



FIGURE 7 Intraoral picture showing the CAFIP in position, with improved esthetics when compared to the patient initial situation

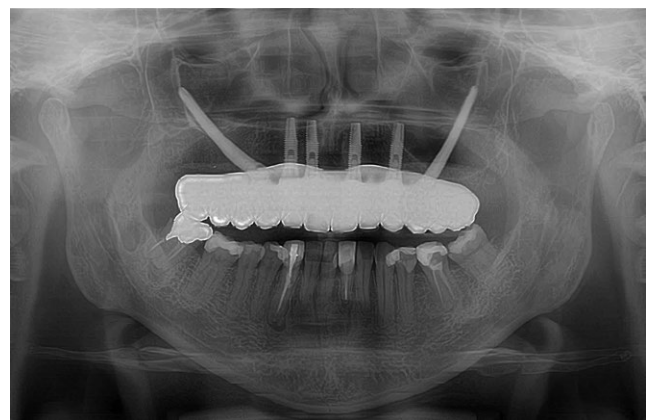


FIGURE 8 Panoramic X-ray showing the final condition of the patient. The CAFIP was constructed with full-contour zirconium oxide, with a radiopaque effect in the X-ray

Some limitations can be associated with the presented workflow, as it did not include an interim prosthesis to check the esthetic and functional outcomes. This was only possible because the previous prosthesis presented a good overall result and was considered a trustworthy reference to be

TABLE 1 Summary of key the clinical steps involved in the proposed digital workflow for the replication of a previously existing prosthesis into new restoration

Process	Device	Objective	Observation
Intraoral scanning	Trios 3shape Scanner	To record the implant tridimensional positions, along with soft tissue contours	The previous prosthesis was also scanned as a reference in a dual-scan protocol
Restoration design (CAD)	Dental System, 3shape	To design a new restoration to match the general dimensions of the previous version	Some cutbacks were done to include Ti-based insertions; also at the buccal side of the anterior teeth and at the gingival region
Restoration milling (CAM)	Ceramill Motion 2; Amann Girschbach	To fabricate the framework for the final restoration	One translucent zirconia blank was used, and after milling, the framework was then sintered
Framework try-in	Ceramill Zolid; Amann Girschbach	To access the fit and the occlusion of obtained with the framework	Other aspects of the prosthesis could be analyzed such as vertical dimension; and palatal or buccal volumes
Ceramic veneering	Emax Ceram, Ivoclar	To achieve the final esthetic results at the gingival and buccal anterior regions	The ceramic was veneered onto the structure without a working model
Ti-based abutments cementation	IMAC 04; SIN Implants	To secure the Ti-based abutments into the zirconia framework	A composite resin cement was used for the cementation directly in mouth
Rehabilitation delivery		To deliver the prosthetic rehabilitation to the patient	Patient hygiene and the overall behavior of the rehabilitation were accessed up to a 3-month follow-up period

replicated. Eventually in patients, which the previous prosthetic result presents issues regarding esthetics, vertical dimension, or occlusion, a new interim prosthesis should be created prior to the intraoral scan.¹⁶

The fabrication of a maxillary CAFIPs through intraoral scan is theoretically easier than a mandibular one because the palatal vault and rugae are more recognizable references for the scanner, rather than the more mobile soft tissues at the mandibular arch.¹² Scanning the palatal surface anatomy proved to be tricky and necessary in the present workflow and should be included in the maxillary construction of full-arch rehabilitations.

The digital, model-less workflow did efficiently cut down turnaround time, as the process was more efficient than conventional methods,^{1,8} and diminishing the possibility of human errors.¹⁰ However, the implementation of such workflow proved to be challenging, requiring advanced skills in clinical and laboratory procedures. A summary of key the clinical steps involved in the proposed digital workflow are enlisted in Table 1.

4 | CONCLUSION

This clinical report demonstrated the treatment with one maxillary implant-supported interim complete fixed dental prosthesis with a contemporary digital approach. All the required diagnostic data were acquired in a single visit, which reduced the overall treatment cost and time for the proposed treatments.

ACKNOWLEDGMENTS

The authors acknowledge the dental laboratory EsteticArt, São Paulo, Brazil, for laboratory work.

CONFLICT OF INTEREST

The authors declare no conflict of interest, directly or indirectly, with regard to any entity that is commercially related to the products mentioned in this clinical report.

AUTHOR CONTRIBUTION

RAM: has coordinated clinical and laboratory works and was responsible for the intraoral scanning procedure that led to the construction of the CAFIP. MAFF: has contributed in several of the clinical procedures described. EV: has contributed with treatment planning and scanning procedures.

ORCID

Roberto A. Markarian  <https://orcid.org/0000-0003-3281-6891>

REFERENCES

1. Brånemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand J Plast Reconstr Surg*. 1969;3:81-100.

2. Able FB, Sartori I, Thomé G, Melo A. Retrospective, cross-sectional study on immediately loaded implant-supported mandibular fixed complete-arch prostheses fabricated with the passive fit cementation technique. *J Prosthet Dent.* 2017;119(1):60-66.
3. Kapos T, Evans C. CAD/CAM technology for implant abutments, crowns, and superstructures. *Int J Oral Maxillofac Implants.* 2014;29:117-136.
4. Pozzi A, Tallarico M, Mangani F, Barlattani A. Different implant impression techniques for edentulous patients treated with CAD/CAM complete-arch prostheses: a randomised controlled trial reporting data at 3 years post-loading. *Eur J Oral Implantol.* 2013;6:325-340.
5. Cardelli P, Manobianco FP, Serafini N, Murmura G, Beuer F. Full-arch, implant-supported monolithic zirconia rehabilitations: pilot clinical evaluation of wear against natural or composite teeth. *J Prosthodont.* 2015;25:629-633.
6. Papaspyridakos P, Gallucci GO, Chen CJ, Hanssen S, Naert I, Vandenberghe B. Digital versus conventional implant impressions for edentulous patients: accuracy outcomes. *Clin Oral Implants Res.* 2016;27:465-472.
7. Papaspyridakos P, Rajput N, Kudara Y, Weber HP. Digital workflow for fixed implant rehabilitation of an extremely atrophic edentulous mandible in three appointments. *J Esthet Restor Dent.* 2017;29(3):178-188.
8. Gherlone E, Capparé P, Vinci R, Ferrini F, Gastaldi G, Crespi R. Conventional versus digital impressions for "all-on-four" restorations. *Int J Oral Maxillofac Implants.* 2016;31:324-330.
9. Mangano FG, Veronesi G, Hauschild U, Mijiritsky E, Mangano C. Trueness and precision of four intraoral scanners in oral implantology: a comparative in vitro study. *PLoS ONE.* 2016;11(9):e0163107.
10. Renouard F, Amalberti R, Renouard E. Are, "human factors" the primary cause of complications in the field of implant dentistry? *Int J Oral Maxillofac Implants.* 2017;32:55-61.
11. Renne WG, Evans ZP, Mennito A, Ludlow M. A novel technique for reference point generation to aid in intraoral scan alignment. *J Esthet Restor Dent.* 2017;29(6):391-395.
12. Gan N, Xiong Y, Jiao T. Accuracy of intraoral digital impressions for whole upper jaws, including full dentitions and palatal soft tissues. *PLoS ONE.* 2016;11(7):e0158800.
13. Caramês J, Mata A, Marques D, Oliveira F. Ceramic-Veneered zirconia frameworks in full-arch implant rehabilitations: a 6-month to 5-year retrospective cohort study. *Int J Oral Maxillofac Implants.* 2016;31:1407-1414.
14. Tartaglia GM, Maiorana C, Gallo M, Codari M, Sforza C. Implant-supported immediately loaded full-arch rehabilitations: comparison of resin and zirconia clinical outcomes in a 5-year retrospective follow-up study. *Implant Dentistry.* 2016;25(1):74-82.
15. Caramês J, Suinaga LT, Yu YC, Pérez A, Kang M. Clinical advantages and limitations of monolithic zirconia restorations full arch implant supported reconstruction: case series. *Int J Dent.* 2015;2015: Article ID 392496, 7 pages.
16. Bidra AS, Tischler M, Patch C. Survival of 2039 complete arch fixed implant-supported zirconia prostheses: a retrospective study. *J Prosthet Dent.* 2017;119(2):220-224.
17. Papaspyridakos P, Kang K, DeFuria C, Amin S, Kudara Y, Weber HP. Digital workflow in full-arch implant rehabilitation with segmented minimally veneered monolithic zirconia fixed dental prostheses: 2-year clinical follow-up. *J Esthet Restor Dent.* 2018;30(1):5-13.
18. Markarian RA, Galles DP, França F. Scanning electron microscopy analysis of the adaptation of single-unit screw-retained computer-aided design/computer-aided manufacture abutments after mechanical cycling. *Int J Oral Maxillofac Implants.* 2018;33(1):127-136.

How to cite this article: Markarian RA, Feitosa Filho M, Vasconcelos E. Model-less digital workflow for the replication of an existing complete fixed implant-supported prosthesis using an intraoral scanner. *Clin Case Rep.* 2019;7:500–505. <https://doi.org/10.1002/ccr3.2012>