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Technical Note

Full-Arch, Implant-Fixed Complete Dentures in Monolithic Zirconia and Titanium: A Digital Workflow to Maximize Cost Effectiveness

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Abstract: Different techniques can be used to design and manufacture a full-arch, implant-supported prosthesis, and different materials can be chosen for its production, each with its advantages and limitations. One of the possibilities provided by digital tools is their ability to maintain low costs to give more patients the chance to choose this commonly expensive treatment. The present work aims to present a protocol for the realization of full-arch, implant-fixed complete dentures (IFCDs) in monolithic zirconia and titanium. When the analogic master model is obtained, it is scanned to perform the digital wax-up, and the two parts of the prosthesis—a bar in titanium and an aesthetic component in monolithic zirconia—are milled. The dental team must then verify the precision of the milled components on the master model, so that they can be cemented together and delivered to the patient. This technique offers different advantages, in terms of cost sustainability, minimal wear risk for the prosthesis and its antagonists, and ease of re-intervening in the case of complications. The main limitations of the technique may lie in the aesthetic needs of the patient, because of the relatively poor aesthetic performance of monolithic zirconia and the absence of a pink orthopedic component.

Keywords: implant dentistry; zirconia; full-arch rehabilitation; technique; CAD-CAM

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1. Introduction

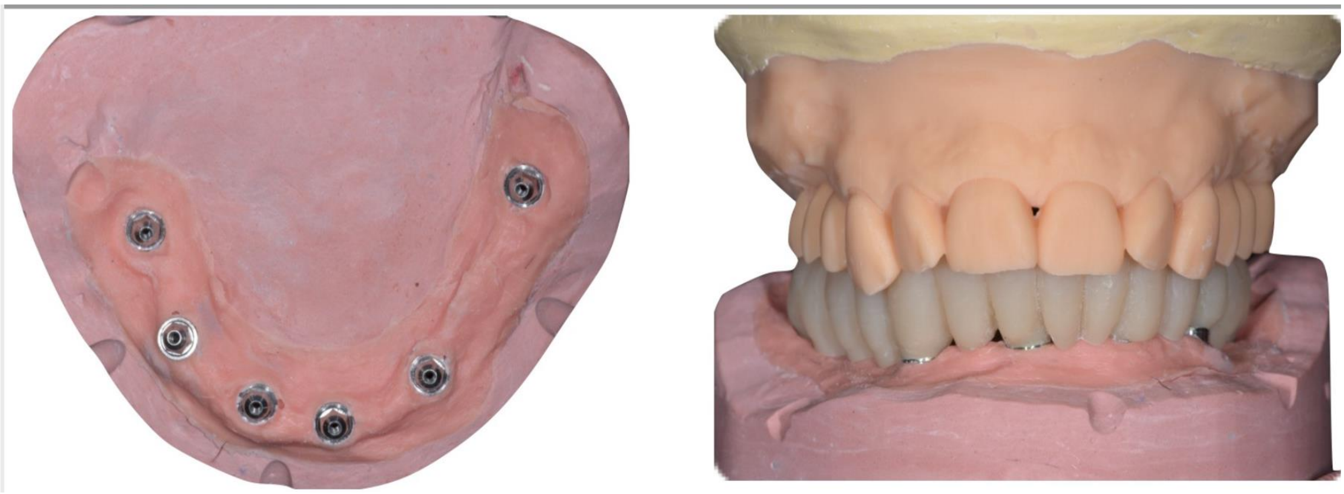
Full edentulism is considered a disability by the World Health Organization (WHO), and, if not properly treated, it seriously impacts the quality of life and can lead to severe systemic consequences [1]. This condition is also largely present in developed countries, where up to 58% of people older than 65 years suffer from it [2]. There are the following two types of rehabilitation that can be proposed to fully edentulous patients: an implant-supported fixed prosthesis or a removable denture. Even if correctly manufactured, dentures do not always guarantee patient satisfaction. Indeed, many patients treated with this approach report that they do not always feel comfortable, especially when they have to remove the denture to perform oral hygiene maneuvers. An implant-supported fixed prosthesis can, instead, put the patient at more ease, both physically and psychologically, restoring a condition that is very similar to the original physiologic situation [3]. The evolution and spread of technologies, techniques, and digital tools in dentistry has allowed more and more clinicians to propose implant-supported rehabilitations to their patients, opening the possibility for more people to improve their quality of life. Many techniques and materials can be used in manufacturing a full-arch, implant-supported fixed prosthesis, and the choice is based on the clinician's preferences and on the patient's needs [4]. Implant-supported rehabilitations, however, are usually expensive and, therefore, are only affordable to a small number of patients suffering from full edentulism [5]. The following protocol describes how to manufacture an implant-supported, full-arch fixed prosthesis, keeping it low cost, so that more clients can access this elite therapy, thanks to fast and repeatable procedures and to the exclusive use of CAD/CAM-produced parts. In fact, the production of implant-supported, fixed complete dentures through an analogic workflow is an expensive and time-consuming procedure. Digital tools can easily reduce production times and, therefore, the final cost [6].

2. Technique

1. The patient receives an immediate loaded, full-arch, implant-supported fixed provisional prosthesis, which makes her/him feel comfortable, both functionally and aesthetically.
2. When the implants reach osteointegration and the soft tissues are stable, an analogic impression is taken to cast a master model, and the provisional prosthesis is relined with the impression material to obtain a perfect impression of the soft tissues (Figure 1a,b).
3. The models are mounted in an articulator (Figure 2a,b). A lab scanner is used to obtain corresponding digital models (Figure 3a,b).
4. Digital wax-up is performed with a CAD-CAM software (Figure 4a,b).
5. After checking the projects, the components—a titanium bar and an aesthetic coating part in monolithic zirconia—are milled with a CAM milling machine. In the case shown as an example of zirconia, Katana STML (Kuraray Noritake, Japan) was used (Figure 5a,b).
6. The precision of the components on the analogic models is verified, paying specific attention to the passivity of the titanium bar on the implants.
7. Stains and glaze are applied to the aesthetic component (Figure 6a,b).
8. The monolithic zirconia component is cemented onto the titanium bar using a dual-curing luting composite (Figure 7a,b).
9. The prosthesis in the patient's mouth is checked by fixing it on the implants (Figure 8a,b).
10. The screw access hole is closed with Teflon and composite.

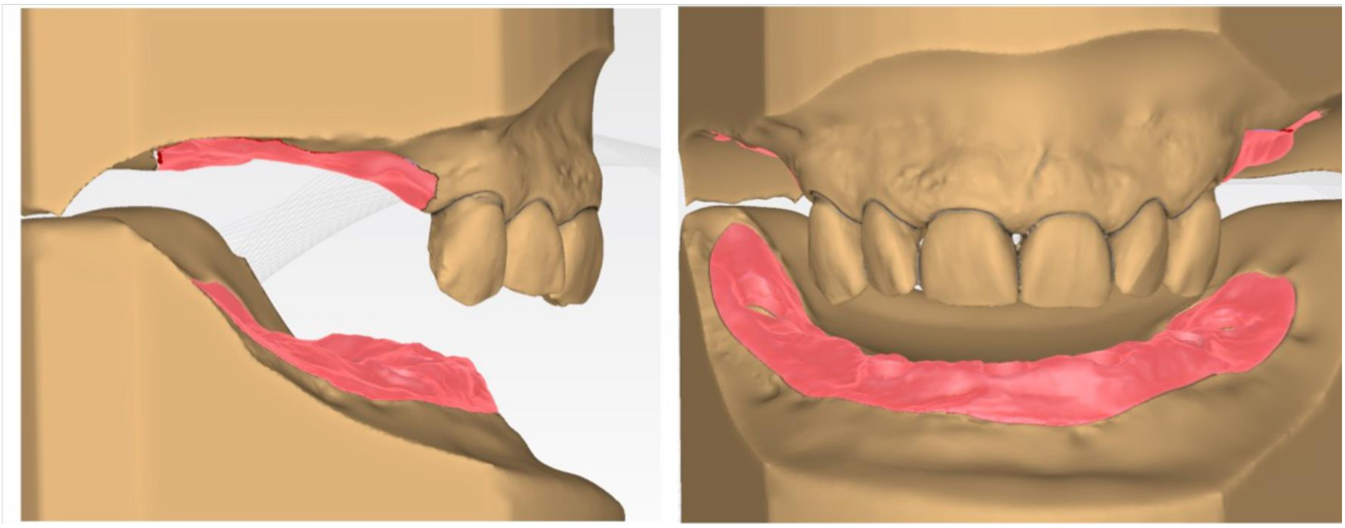
(a) (b)

Figure 1. (**a**,**b**) Provisional prosthesis relined with impression material.



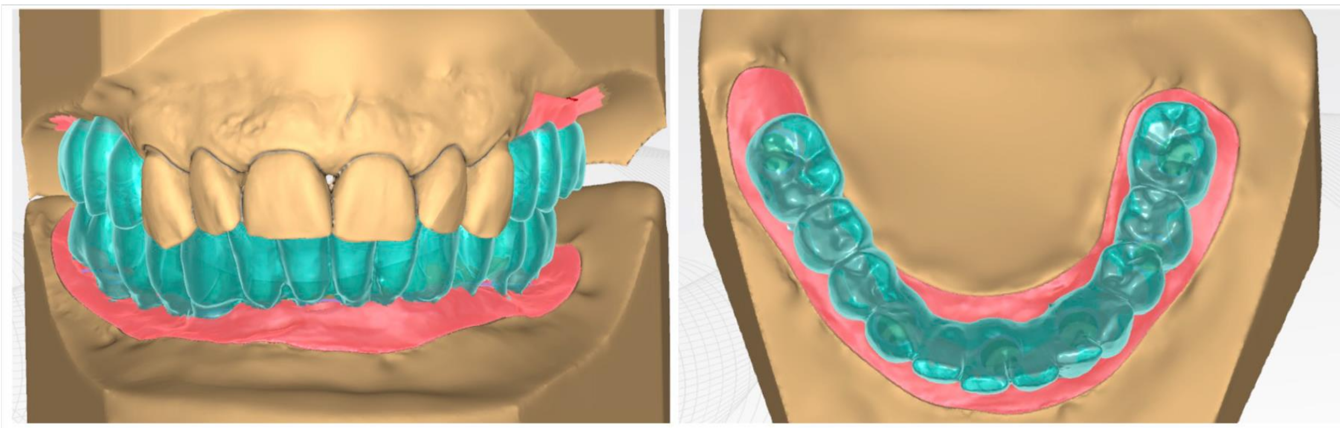
(**a**) (**b**)

Figure 2. (**a**,**b**) Master models.



(**a**) (**b**)

Figure 3. (**a**,**b**) Digital master models.



(**a**) (**b**)

Figure 4. (**a**,**b**) Digital wax-up.

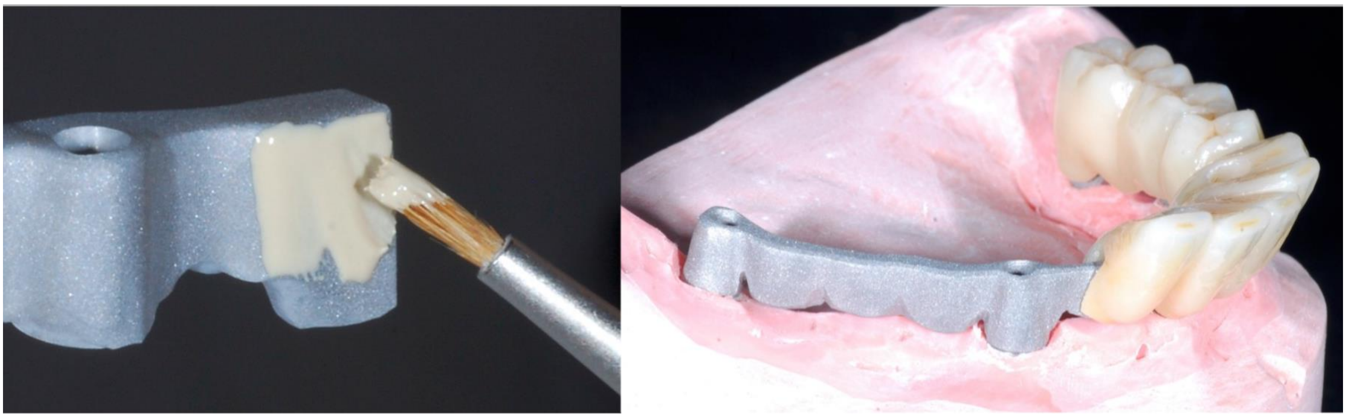
(**a**) (**b**)

Figure 5. (**a**,**b**) Titanium bar and monolithic zirconia component.

(**a**)

(**b**)

Figure 6. (**a**,**b**) Staining of monolithic zirconia.



(**a**) (**b**)

Figure 7. (**a**,**b**) Cementing phase.

(**a**)

(**b**)

Figure 8. (**a**,**b**) Final result.

3. Discussion

In modern dentistry, full-arch, implant-supported rehabilitations represent the gold standard treatment for patients who are edentulous or have failing dentition. In recent years, the development of new technologies, particularly in implantology and prosthodontics, has granted the possibility to rely on safer and more predictable procedures, also reducing the operating time, both on the chair and in the lab [7]. Different methods have been proposed to design and produce full-arch, implant-supported prostheses, including some that involve digital tools, each with their own indications, advantages, and limitations. Based on the patients' needs and their own experience, clinicians can choose which protocol to follow, the number of implants to place, the loading time, the impression techniques, and the materials to use [4]. Some of these solutions are more expensive than others. To keep the costs low, metal–resin prostheses are often considered the correct choice as a definitive solution. However, these materials have been shown to be more likely to cause severe complications than ceramic materials, such as fracture and wear, leading to higher final costs [8]. Although it does not represent an urgency according to the patients' perception, as it occurs slowly, without their full awareness, wear is a very unfavorable occurrence, as it leads to alterations in the intermaxillary relationship and the vertical dimension originally established [9]. The procedure proposed in this work merges the possibility of obtaining a prosthesis that is less likely to run into complications than a metal–resin prosthesis with the chance to reduce production, maintenance, and repair costs. Indeed, studies on the mechanical properties of monolithic zirconia have highlighted that this material is not only very wear resistant, but also guarantees a lower degree of wear to the antagonist teeth, allowing the original intermaxillary relationships to be maintained over time [10,11]. Another protocol to obtain a prosthesis with an anatomical component in monolithic zirconia cemented onto a titanium bar obtained with CAD/CAM systems is that proposed by Scarano et al. [12]. This, however, requires stratification of the zirconia component to obtain a more aesthetically performant result. Instead, the procedure presented here does not involve monolithic zirconia stratification, but just its characterization with stains. This has the following different advantages: it reduces costs and the eventuality of chipping, and, in the case of complications, it enables the designed monolithic zirconia component to be milled again, and to be re-cemented onto the titanium bar. Whether it was necessary to modify the milled bar or not, due to the loss of an implant, it would be enough to re-mill the modified bar, this time preserving the zirconia part, since, once cemented, the two components can be easily separated using heat. Scarano and colleagues also showed, in 16 cases without failures or severe complications, that implant-fixed complete dentures made of a titanium bar and zirconia crowns can obtain excellent results after a 5-year follow-up [12]. The limitations of this procedure are the lack of a pink orthopedic component and the absence of stratification, even in the aesthetic zone. For these reasons, the proposed technique finds its main indication in patients with limited economic possibilities and without great aesthetic demands.

4. Conclusions

The presented protocol represents an effective, low-cost solution that is easily and quickly repairable, which leads to complete restoration of the masticatory function and reaches an excellent aesthetic compromise, giving the possibility of a greater number of patients to significantly improve their quality of life.

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References

1. Gupta, A.; Felton, D.A.; Jemt, T.; Koka, S. Rehabilitation of Edentulism and Mortality: A Systematic Review. *J. Prosthodont.* **2019**, *28*, 526–535. [CrossRef] [PubMed]
2. Polzer, I.; Schimmel, M.; Biffar, R. Edentulism as part of the general health problems of elderly adults. *Int. J. Dent.* **2010**, *60*, 143–155.
3. Att, W.; Stappert, C. Implant therapy to improve quality of life. *Quintessence Int.* **2003**, *34*, 573–581.
4. Schoenbaum, T.R.; Guichet, D.L.; Jang, J.Y.; Kim, Y.K.; Wadhwani, C.P.K. Clinician preferences for complete-arch fixed implant-supported prostheses: A survey of the membership of the Pacific Coast Society for Prosthodontics. *J. Prosthet. Dent.* **2020**, *124*, 669–705. [CrossRef]
5. Babbush, C.A.; Kanawati, A.; Kotsakis, G.A.; Hinrichs, J.E. Patient-related and financial outcomes analysis of conventional full-arch rehabilitation versus the all-on-4 concept: A cohort study. *Implant Dent.* **2014**, *23*, 218–224. [CrossRef]
6. Van Noort, R. The future of dental devices is digital. *Dent. Mater.* **2012**, *28*, 3–12. [CrossRef] [PubMed]
7. Joda, T.; Ferrari, M.; Gallucci, G.O.; Wittneben, J.-G.; Brägger, U. Digital technology in fixed implant prosthodontics. *Periodontology* **2017**, *73*, 178–192. [CrossRef] [PubMed]
8. Barootchi, S.; Askar, H.; Ravidà, A.; Gargallo-Albiol, J.; Travan, S.; Wang, H.L. Long-term clinical outcomes and cost-effectiveness of full-arch implant-supported zirconia-based and metal-acrylic fixed dental prostheses: A retrospective analysis. *Int. J. Oral Maxillofac. Implants* **2020**, *35*, 395–405. [CrossRef]
9. Papaspyridakos, P.; Chochlidakis, K.; Kang, K.; Chen, Y.W.; Alghfeli, A.; Kudara, Y.; Weber, H.P. Digital Workflow for Implant Rehabilitation with Double Full-Arch Monolithic Zirconia Prostheses. *J. Prosthodont.* **2020**, *29*, 460–465. [CrossRef] [PubMed]
10. Kontonasaki, E.; Rigos, A.E.; Ilia, C.; Istantsos, T. Monolithic zirconia: An update to current knowledge. Optical properties, wear, and clinical performance. *Dent. J.* **2017**, *7*, 90. [CrossRef]
11. Jung, Y.S.; Lee, J.W.; Choi, Y.J.; Ahn, J.S.; Shin, S.W.; Huh, J.B. A study on the in-vitro wear of the natural tooth structure by opposing zirconia or dental porcelain. *J. Adv. Prosthodont.* **2010**, *2*, 111–115. [CrossRef] [PubMed]
12. Scarano, A.; Stoppaccioli, M.; Casolino, T. Zirconia crowns cemented on titanium bars using CAD/CAM: A five-year follow-up prospective clinical study of 9 patients. *BMC Oral Heal.* **2019**, *19*, 286. [CrossRef] [PubMed]