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# The Use of Full-Contour Zirconia for Full-Arch Implant-Supported Rehabilitations—A Narrative Review

**N. De Angelis[1] · M. De Lorenzi[2] · F. Presicci[3] · C. Yumang[2] · A. Lazetera[3] · P. Pesce[1]**

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## Abstract

**Purpose of Review** Dental implant-supported rehabilitations have transformed restorative dentistry, utilizing zirconia as a key material. This abstract explores the role of zirconia in full-arch implant-supported rehabilitations, shedding light on its clinical applications and the evidence supporting its use.

**Recent Findings** Zirconia's unique properties, including strength, biocompatibility, and natural translucency, make it versatile for dental applications, including full-arch rehabilitations. In cases of full-arch restorations, zirconia abutments and crowns are commonly used due to their durability and natural appearance. Studies suggest that zirconia is a suitable material for framework structures in implant-supported, full-arch rehabilitations. However, there is a notable incidence of technical complications, mainly ceramic chipping.

**Summary** Zirconia offers strength and biocompatibility, making it suitable for full-arch implant-supported rehabilitations. While it holds promise for aesthetic outcomes, the decision should balance technical feasibility and patient satisfaction. Cost-effectiveness analysis indicates that, despite higher initial costs, zirconia-based restorations can be a valuable long-term investment. Further research is essential to improve zirconia's durability and clinical performance, addressing technical complications. The choice of restorative material should align with specific clinical requirements, considering the material's strengths and weaknesses.

**Keywords** Zirconia · Dental implant-supported rehabilitations · Full-arch restorations · Biocompatibility · Ceramic chipping · Aesthetic outcomes

## Introduction

Dental implant-supported rehabilitations have revolutionized the field of restorative dentistry, offering patients a reliable and aesthetically pleasing solution to edentulism and compromised dentition. Over the years, the materials used for prosthodontic components have evolved significantly. Several materials are available and zirconia has emerged as a prominent choice due to its excellent mechanical properties, biocompatibility, and aesthetic advantages [1, 2••]. This introduction delves into the compelling role of zirconia in full-arch implant-supported rehabilitations, shedding light on its clinical applications and the evidence supporting its use.

Zirconia, a ceramic material derived from zirconium dioxide, has gained widespread recognition in dentistry. Its unique properties, including high strength, resistance to wear, biocompatibility, and natural translucency, make it a versatile material for dental applications including both partial- and full-arch rehabilitations. Zirconia is now employed for various prosthodontic components, including implant-supported crowns, bridges, and abutments [1].

The use of zirconia is nowadays documented also for four-implant-supported rehabilitations, commonly seen in cases of full-arch restorations. These rehabilitations involve the placement of four dental implants in a patient's jawbone, followed by the attachment of a prosthetic superstructure. Zirconia abutments and crowns are frequently used in these cases due to their durability and natural appearance. Zirconia abutments offer excellent biocompatibility and are known for their ability to resist

✉ N. De Angelis
n.deangelis74@gmail.com

[1] Department of Surgical Sciences and Integrated Diagnostics, University of Genoa, Genoa, Italy

[2] Acqui Terme, Italy

[3] CDT Lab. Lazetera, Savona, Italy

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corrosion [3]. This makes them suitable for long-term use in implant-supported rehabilitations. Moreover, zirconia abutments can be customized to achieve a precise fit, promoting proper soft tissue management around the implant, which is crucial for aesthetic outcomes [4]. Zirconia crowns and bridges are prized for their superior strength, minimizing the risk of fractures or chipping [3]. In full-arch rehabilitations, zirconia crowns and bridges can efficiently distribute occlusal forces, ensuring the longevity of the prosthetic restoration [5•].

Additionally, in contrast with first generation zirconia, nowadays the translucency of zirconia might mimic that of natural teeth, making it a popular choice for aesthetic restorations.

Zirconia can be easily milled, sintered, and colored, in order to reproduce and mimic the anatomy and the shape of natural teeth (Fig. 1a–c).

In case of full-arch rehabilitations, a titanium bar can be inserted and fixed inside the full zirconia, in order to minimize the stresses and to add strength to the entire structure (Fig. 2a–c).

In vitro studies demonstrated that a rigid substructure optimize occlusal load distribution in full-arch prosthesis compared to full-acrylic restorations [6, 7].

However, due to excessive rigidity, some authors have questioned the use of zirconia in implant-supported restorations [8, 9].

The aim of the present narrative review is to enlighten the most common questions in the clinical field regarding the use of zirconia in full-arch implant-supported restorations, in order to guide the clinicians toward a rationale and evidence-based choice of the material for full-arch implant supported restorations.

## Methods

### Search Strategy

A comprehensive search strategy was performed on PubMed, Medline, EMBASE, and Google Scholar for articles matching the following key words: *zirconia and/or full-arch implant restorations*; *zirconia and/or esthetic outcomes*; *full-larch implant restorations and/or complications.*

### Focused Questions

Literature search was addressed to answer the following questions:

a- Are zirconia full-arch implant restorations reliable?
b- How common are the complications on full arch implant restorations in zirconia?
c- Is zirconia preferable than other materials for aesthetic outcomes?

The studies had to meet the following inclusion criteria:

- clinical studies (retrospective and prospective);
- studies including full-arch rehabilitations;
- studies including also zirconia full-arch rehabilitations.

**Fig. 1** Case of double full-arch rehabilitations in zirconia **a** after milling and **b**, **c** after sintering. CDT Lab. Lazetera Savona, Italy

**Fig. 2** **a** The titanium bars are inserted inside the zirconia framework; **b** articulation check on the casts after painting and polishing; **c** delivery

In vitro and animal studies were excluded during the search.

## Results

The search from 2007 and 2023 produced 41 results but only 10 were judged eligible clinical trials (retrospective and prospective) for the scope of this narrative review. Five systematic reviews matching the search criteria were also identified.

In Table 1 the included studies are reported.

### Are zirconia Full Arch Implant Restorations Reliable?

Manicone et al. [10] in their preliminary study report the potential use of zirconia for manufacturing dental devices. No data were reported in terms of mechanical strength and shock absorption.

**Table 1** Included studies

| Year | Author | Title |
|---|---|---|
| 2007 | Manicone, PF. Rossi I., Pierfrancesco R., et al. [10] | An overview of zirconia ceramics: Basic properties and clinical applications |
| 2015 | Pozzi, A. Tallarico, M. Barlattani, A [11]. | Monolithic lithium disilicate full-contour crowns bonded on CAD/CAM zirconia complete-arch implant bridges with 3 to 5 years of follow-up |
| 2016 | Cardelli, P. Manobianco, F. P. Serafini, N. Murmura, G. Beuer, F [12]. | Full-arch, implant-supported monolithic zirconia rehabilitations: Pilot clinical evaluation of wear against natural or composite teeth |
| 2016 | Mendez Caramês, J.M. Sola Pereira da Mata, António D. da S. M., Duarte N. de Oliveira , Helena C [13]. | Ceramic-veneered zirconia frameworks in full-arch implant rehabilitations: A 6-month to 5-year retrospective cohort study |
| 2016 | Tartaglia, G.M. Maiorana, C. Gallo, M. Codari, M. Sforza, C [14] | Implant-supported immediately loaded full-arch rehabilitations: Comparison of resin and zirconia clinical outcomes in a 5-year retrospective follow-up study |
| 2018 | Morton D. et al. [4] | Group 2 ITI consensus report: Prosthodontics and implant dentistry |
| 2019 | Caramês, J. Marques, D. Malta Barbosa, J. Moreira, A. Crispim, P. Chen, A [15]. | Full-arch implant-supported rehabilitations: A prospective study comparing porcelain-veneered zirconia frameworks to monolithic zirconia |
| 2020 | Papaspyridakos, P. Chochlidakis, K. Kang, K. Chen, YW Alghfeli, A. Kudara, Y. Weber, HP. [16] | Digital workflow for implant rehabilitation with double full-arch monolithic zirconia prostheses |
| 2020 | Barootchi, S. Askar, H. Ravidà, A. Gargallo-AJ. Travan, S. Wang, Hom-Lay [17•] | Long-term clinical outcomes and cost-effectiveness of full-arch implant-supported zirconia-based and metal-acrylic fixed dental prostheses: A retrospective analysis |
| 2022 | Tirone, F. Salzano, S. Rolando, E. Pozzatti, L. Rodi, D [18••]. | Framework fracture of zirconia supported full arch implant rehabilitation: A retrospective evaluation of cantilever length and distal cross-sectional connection area in 140 patients over an up-To-7 year follow-up period |

Pozzi et al. [11] tested zirconia complete-arch implant bridges, to overcome the drawbacks related to the chipping of porcelain fused to zirconia restorations. The results reported only one out of 18 full arch restoration showed a material chipping that was polished intraorally, without any further treatment.

Cardelli et al. [12] investigated in a clinical study the wear extent of the opposite arches of natural teeth or composite over full-arch zirconia restorations. The conclusion after 1 year of observation was that monolithic zirconia full-arch rehabilitations induced a clinically acceptable wear on natural and composite antagonists.

Mendez et al. [13] in a 5-year retrospective clinical study observed the behavior of full-arch zirconia restorations and the conclusion was that zirconia is a suitable material for framework structure in implant-supported, full-arch rehabilitations. However, it experiences a high incidence of technical complications, mainly due to ceramic chipping.

Morton D. et al. [4] at the ITI Consensus Conference in 2018 reported that clinical performance of zirconia and metal ceramic single-implant supported crowns is similar and each demonstrates significant, though different, complications. Zirconia ceramic FDPs are less reliable than metal ceramic. Implant-supported monolithic zirconia prostheses may be a future option with more supporting evidence.

Carames et al. [13] compared porcelain-veneered zirconia frameworks to monolithic zirconia in full-arch implant-supported rehabilitations and the conclusions were that monolithic zirconia group presented a lower technical complication rate, thus presenting itself as a viable alternative for full-arch implant-supported rehabilitations.

Barootchi et al. [17•] compared in a retrospective analysis the clinical outcomes and cost-effectiveness of full-arch implant-supported zirconia-based and metal-acrylic fixed dental prostheses. The conclusions were that zirconia-fixed implant prostheses presented higher initial costs than metal-acrylic hybrids, however, with satisfactory outcomes, reduction of overall complications, and superior survival rates.

### How Common Are the Complications on Full Arch Implant Restorations in Zirconia?

Tartaglia et al. [14] compared implant-supported immediately loaded full-arch rehabilitations: comparison of resin and zirconia clinical outcomes. The reported results were that during the follow-up interval, the prosthesis annual complication rate was 6.6%, where age, number of implants, and prosthesis material did not influence failure risk.

Barootchi et al. [17•] evaluated the long-term clinical outcomes of full-arch implant-supported zirconia-based and metal-acrylic fixed dental prostheses. The results of this retrospective study were that delayed complications accompanied the metal-acrylic prostheses more frequently than zirconia, which showed higher prosthetic survival rates.

Tirone et al. [18••] made a retrospective evaluation of cantilever length and distal cross-sectional connection area in 140 patients over an up to 7-year follow-up. They introduced the classification of type 1 fractures that happened between but not involving the two most posterior screw-access openings and type 2 of the distal cantilever. During the period of observation 10 prostheses failed (5.6% prosthetic failure rate): 2 because of implant failures and 8 because of framework fractures. Five fractures were classified as type I and three as type II. Significant associations were found between cantilever length and type I fractures, distal connector cross-sectional area and type II fractures. Cantilever length and the total number of fractures were also proportional. The ratio between the cantilever length and cross-sectional connector area was suggested to be $< 0.51$, while the ratio between the cantilever length and screw access opening was recommended $< 1.48$.

### Is Zirconia Preferable than Other Materials for Aesthetic Outcomes?

Manicone et al. [10] reported a higher aesthetic performance for zirconia abutments and zirconia-based prostheses.

Papaspyridakos et al. [16] described a fully digital approach on hopeless dentition and reported a successful integration of the zirconia-based full-arch rehabilitations.

None of the other included studies reported aesthetic results.

## Discussion

The studies reviewed provide a comprehensive perspective on the potential of zirconia in dental restorations. Zirconia, a type of ceramic known for its exceptional strength and biocompatibility, has gained popularity in dental applications. However, understanding its limitations and potential risks is crucial. In this discussion, we will delve deeper into the findings of the various studies and explore the implications of using zirconia in dental restorations.

Manicone et al.'s [10] preliminary study reported the potential use of zirconia for manufacturing dental devices. While this study served as a preliminary exploration, the lack of data on mechanical strength and shock absorption in zirconia raises questions about its comprehensive suitability for dental devices. The absence of these critical mechanical properties data underscores the need for more extensive research to evaluate the performance and durability of zirconia in the demanding environment of dental devices.

In vitro studies [8] measured the chewing load forces transmitted through crowns made of different prosthetic restorative materials onto the dental implant by using an

automated masticatory system. The results of this investigation reported that zirconia and ceramic crowns transmitted significantly greater forces than the other materials tested.

The authors concluded that composite and acrylic resin crowns were more able to absorb shock from occlusal forces than crowns made of zirconia, ceramic material, or gold alloy.

A finite element analysis [6] compared metal frameworks and carbon fiber–reinforced frameworks with full-acrylic prostheses to have less heavy structures. The authors concluded that the presence of a rigid framework in full-arch fixed prostheses provides a better load distribution that decreases the maximum values of stress at the levels of implants, prosthesis, and maxillary bone. This brings up a critical consideration: while zirconia's robustness is an asset in resisting wear and tear, the increased force transmission could potentially lead to issues with the natural dentition and dental implants. In a recent systematic review [19] the authors evidenced that when zirconia was used as framework material, the reasons for failure were primarily biological and technical complications other than framework fracture, which can match with findings of the present review, especially connected to occlusal forces transmitted to the opposite arches.

The issue of technical complications looms large in the context of zirconia restorations, as indicated by studies conducted by Pozzi, Cardelli, and Mendez [11–13]. They found that zirconia-based restorations experienced a notable incidence of ceramic chipping, which had significant clinical implications. While zirconia's strength is advantageous in resisting wear and fractures, it appears to come at the cost of potential brittleness, which may lead to chipping or fracture under certain conditions. Understanding the factors contributing to this chipping, such as occlusal forces and material properties, is vital for clinicians and researchers. Strategies to minimize these technical complications and enhance the resilience of zirconia in clinical practice need to be explored. Raigrodski et al. [20] in a systematic review described zirconia-based prostheses as a viable option for full-arch implant rehabilitation, but were not able to establish long-term results.

Similar findings were retrieved also by Delucchi et al. [2••] and Abdulmajeed et al. [21] in a more recent reviews, where its results are still unclear to clarify the specific clinical indications and manufacturing protocols of these newly introduced materials, as well as the optimization of their clinical outcomes.

Morton et al.'s [4] comparison of zirconia and metal-ceramic restorations highlights that while both exhibit complications, they differ in nature, necessitating considerations for clinical decision-making and patient outcomes. This comparison suggests that selecting the appropriate material for a specific clinical case is essential. While zirconia and metal-ceramic restorations both offer advantages, they also come with unique sets of complications. Understanding these differences is crucial for tailoring treatment plans to individual patient needs and minimizing the risk of complications. The decision between these materials must consider factors like aesthetics, material properties, and the patient's specific clinical needs.

Poggio et al. [1] concluded their systematic review recommending that the proper choice of the material should be mostly related on clinicians' own experience, until fully validated protocols are not available.

The study by Carames et al. [13] comparing porcelain-veneered zirconia frameworks to monolithic zirconia in full-arch implant-supported rehabilitations is particularly interesting. Their findings indicate that the monolithic zirconia group presented a lower technical complication rate, making it a viable alternative. This comparison underscores the potential advantages of monolithic zirconia in terms of reducing complications and simplifying clinical procedures. However, it also raises questions about the aesthetics of monolithic zirconia and how it compares to veneered zirconia in terms of patient satisfaction. The balance between technical feasibility and aesthetic considerations is a key decision point in dental restorations.

An interesting topic was introduced by Tirone et al. [18••], where the risk of fracture was related to the cantilever length and, as unique definite protocol, the ratio between the cantilever length and screw access opening length should be $< 1.48$, and the ratio between the cantilever length and cross-sectional connector area should be $< 0.51$.

Lastly, the cost-effectiveness analysis by Barootchi et al. shows that while zirconia prostheses have higher initial costs, their superior survival rates and reduced complications may make them a worthy long-term investment. However, it is essential to consider individual patient needs and clinical factors when making decisions regarding restorative materials. The economic aspects of choosing zirconia versus other materials are integral to the decision-making process and highlight the long-term value of investing in zirconia-based restorations. In a systematic review [22] zirconia restorations on implants were compared to metal-ceramic ones. No differences in terms of biological complications were found, but significantly higher amount of zirconia failed due to material fractures. This kind of complications may not be easily repaired with intra-oral interventions, like metal-ceramic restorations [23].

## Conclusions

Zirconia holds great promise in dental restorations due to its exceptional strength and biocompatibility. However, the studies discussed in this review reveal certain complexities and trade-offs associated with its use. The increased force transmission suggests that while zirconia may be suitable

for specific applications, it may not be ideal for all clinical cases. The technical complications, particularly ceramic chipping, highlight the importance of ongoing research to improve the material's durability and clinical performance.

Comparisons with other materials, as presented by Morton et al., emphasize the need for informed decision-making when selecting restorative materials, taking into consideration the specific clinical requirements and potential complications associated with each material.

In light of the studies discussed, it is clear that zirconia has a place in modern dentistry, but its use should be guided by a careful assessment of the clinical context and a thorough understanding of its strengths and weaknesses.

**Author Contribution** NDA and PP wrote the manuscript; FP and AL prepared the figures; MDL and CY revised the final version.

**Data Availability** No datasets were generated or analysed during the current study.

## Compliance with Ethical Standards

**Competing Interests** The authors declare no competing interests.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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