Original Article

Modern concepts in Implant-Supported Fixed Complete Dental Prostheses (IFCDPs): from traditional solutions to current monolithic zirconia restorations. Concise review

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Abstract

Implant-supported fixed complete dental prostheses (IFCDPs) can be made with different prosthetic designs in a wide range of material combinations. The choice of materials and the implant-prosthetic design are closely linked. In the recent past, the combinations of materials used for full-arch fixed prosthetic restorations were exclusively: metal-acrylic resin, metal-composite resin and metal-ceramic. In the last two decades, zirconia frameworks have become increasingly popular in the implant prosthetic field and the introduction of CAD/CAM technology has made it possible to approach full-arch restorations in a different way. The most advanced implant-prosthetic designs exploit the aesthetic and mechanical strength qualities of the latest generation monolithic zirconia. These solutions looks very promising. However, the long-term outcome of these implant-supported rehabilitations remains still unknown due to the lack of sufficient clinical data.

Keywords: Zirconia, monolithic zirconia, metal bar, Implant-supported fixed complete dental prostheses.

Introduction

Implant-supported fixed complete dental prostheses (IFCDPs) represent the therapeutic solution of excellence for total edentulism and demonstrate high clinical success rates in the literature[1,2,3]. IFCDPs have 95% clinical success at 5 years in the maxilla and 97% at 10 years in the mandibular arch[4] .These restorations can be made with different prosthetic designs in a wide range of material combinations chosen based on clinical and economic factors. Therapeutic options differ on the basis of retention methods, framework design, combination of prosthetic materials, gingiva construction methods[3]. In all implant-prosthetic designs we can find advantages and disadvantages related to aesthetics, strength, simplicity, manufacturing method, complications and cost. The choice of materials and the implant-prosthetic design are closely linked. In order to select the most advantageous therapeutic option, in the decision-making process it is essential to know the strengths and weaknesses of the available solutions. The most current solutions make it possible to exploit the translucency potential of the new generations of zirconia which, however, require adequate knowledge of the materials and a correct design evaluation. In this article we expose current knowledge on modern full-arch implant prosthetic solutions in the light of the recent zirconia-based materials offered by the product sector.

Traditional solutions

Historically, resin occlusal surfaces have been used in implant prosthetics to provide a “cushioning effect” to the implants in order to compensate for the resilience of the periodontium and allow the occlusal surface to be the weakest link in the implant prosthetic restoration[5]. With the deepening of knowledge on osseointegration and a greater diffusion of implant prosthesis, the use of metal alloy and ceramic for occlusal surfaces has spread. Currently, there is no scientific evidence showing a link between osseointegration and the type of occlusal surface material. Furthermore, there does not appear to be any differences in terms of stresses transmitted to the bone based on the fabrication material of the occlusal surfaces of the restoration[6]. Nonetheless, fracture of the occlusal material is one of the most common complications reported in the literature[7,8]. In the recent past, the combinations of materials used for full-arch fixed prosthetic restorations were exclusively: metal-acrylic resin, metal-composite resin and metal-ceramic. The metal-acrylic resin combination (Metal framework-prefabricated acrylic artificial teeth) has shown high success rates[9] and remains a popular choice due to its long tradition in literature, simplicity, low cost, simple repair management and a “clinicians comfort level” acquired over the years[10]. The metal-composite resin and metal-ceramic alternatives are both expensive, more laborious to manufacture, difficult to repair and susceptible to the manufacturing technique[11]. All traditional rehabilitation typologies present various complications in the short and long term including: fracture or detachment of resin teeth, wear of occlusal surfaces, ceramic chipping, difficulty in color matching related to gingival pink, lack of passive adaptation, expensive prosthetic repairs[10,12-21].

Zirconia

The recent evolution of ceramic materials in prosthetic dentistry is aimed at increasing the mechanical and aesthetic properties and simplifying the manufacturing and decision-making processes for clinicians and technicians. The interest in zirconia as a framework material derives from the possibility of advantageously exploiting the phase transition (PTT, Phase Transformation Toughening), obtaining a ceramic material with high resistance and fracture toughness. Until a few years ago, it was universally recognized in the literature that the most mechanically resistant ceramics offered less advanced aesthetic characteristics, most of the time resulting more opaque, therefore less translucent and attractive. Thus, in recent years zirconia has undergone changes in microstructural composition to improve translucency while maintaining adequate mechanical properties: with the third generation of zirconia, born in 2015, and the subsequent fourth generation, structural changes have been made starting from the increase of the yttrium oxide content[22,23,24]. Furthermore, the introduction of monolithic zirconia for its characteristics of reliability and practicality has led to a downsizing in prosthetic design with indisputable advantages for clinicians and technicians[25,26]. In the last two decades, zirconia frameworks have become increasingly popular in the implant prosthetic field and the introduction of CAD/CAM technology has made it possible to approach full-arch restorations in a different way and with promising success rates[27-30].

Screw-retained IFCDPs: monolithic zirconia restorations

Monolithic zirconia has recently found an indication in screw-retained full-arch implant prosthetic restorations. In this prosthetic design, the reference material remains the second generation 3Y-TZP for mechanical strength and high success rates: recent studies have shown a survival rate of 99.3% with minimal technical complications in the medium term[31]. These restorations can provide in the CAD phase a digital "cut back" of the structure in the non-functional areas in which the minimum ceramicization is required limited to the aesthetic areas including the gingival part[32,33,34]. The elimination of the zirconia/ceramic interface from the functional surfaces solved the clinical complications related to the delamination or chipping of the veneering layer[3,29,35]. The key to the clinical success of the screw-retained monolithic prosthesis lies in the extreme precision and correct design of the monolithic monoblock, particularly in the areas potentially most exposed to fracture. The distal cantilever, which has a long history of clinical success in full-arch implant prosthetics[36,37], in the case of limited prosthetic space (less than 15mm) or parafunctional habits of prosthetic components at higher risk of mechanical complications[38,39]. In zirconia restorations, cantilevers must be sized with large occlusocervical thicknesses and limited extension in order to withstand high occlusal loads[40]. It is also important to ensure adequate thicknesses of the framework in correspondence with the access chimneys to the connection screws adjacent to the cantilevers[33]. The same attentions in the design phase are valid in the case of anterior cantilevers, a potential cause of catastrophic fracture often underestimated and which require a safety dimensioning of the areas with the greatest risk of failure. The advantages of the monolithic screw-retained prosthesis are many. The screw-retained prosthesis traditionally represents the first choice in full-arch implant-prosthetic rehabilitation for fewer biological complications and easier management of complications[41,42]. Zirconia guarantees advanced mechanical properties with a low complication rate; excellent biocompatibility; favorable wear characteristics; reduced accumulation of plaque and biofilm; satisfactory gingival and dental aesthetics associated with minimal ceramization of non-functional areas; reduced pigmentation compared to acrylic resin. The CAD-CAM design and production of zirconia has led to further advantages: better precision of the prosthesis thanks to modern manufacturing systems; availability of a permanent digital file with the possibility of duplicating the prosthetic restoration; possibility of making temporary posts in PMMA. However, the monolithic zirconia screw-retained design remains a complex prosthetic solution, in which clinical success is linked to the knowledge of the materials and the high precision required by 3Y-TZP[32,33,43]. The need to guarantee the framework suitable dimensions in areas at risk of fracture, the impossibility of recovery of the structure in the event of failure, the low tolerance to imprecisions and the opacity of the high-strength material represent the current limits of this prosthesis[2,33]. The monolithic screw-retained design is not able to take advantage of the progress of the material because it requires high-strength but opaque zirconia, which needs digital cut-back procedures and ceramization of the aesthetic area[34,44]. Even the latest generation multitranslucent materials do not seem to be the adequate answer to the problem as the complex design of the screwed monoblock places too many unknowns on the strength of the structure. However, the new generations of 4Y-TZP and multi-translucent monolithic zirconia materials, incorporating 3Y, 4Y and 5Y-TZP with varying translucency levels, appear to be promising in these designs as well. In particular, some types of 4Y-TZP with high mechanical performance can represent promising materials in this sense.

Metal-Zirconia Implant Fixed Hybrid Full-Arch Prosthesis: monolithic zirconia on metal bar

To overcome these limitations, recent studies have proposed an innovative prosthetic solution that has been defined as a metal-zirconia hybrid for the combination of a metal framework supporting a monolithic structure in zirconia[45,46]. This prosthetic design features a bar, usually in titanium or Cr-Co, to support a latest generation monolithic zirconia superstructure. By exploiting advanced CAD-CAM digital technologies, it is possible to combine the advantages of the two materials, offering aesthetic and reliable restorations (Figg.1-3). The metal bar gives stiffness, excellent tensile strength, high fracture strength, passive fit and allows you to manage

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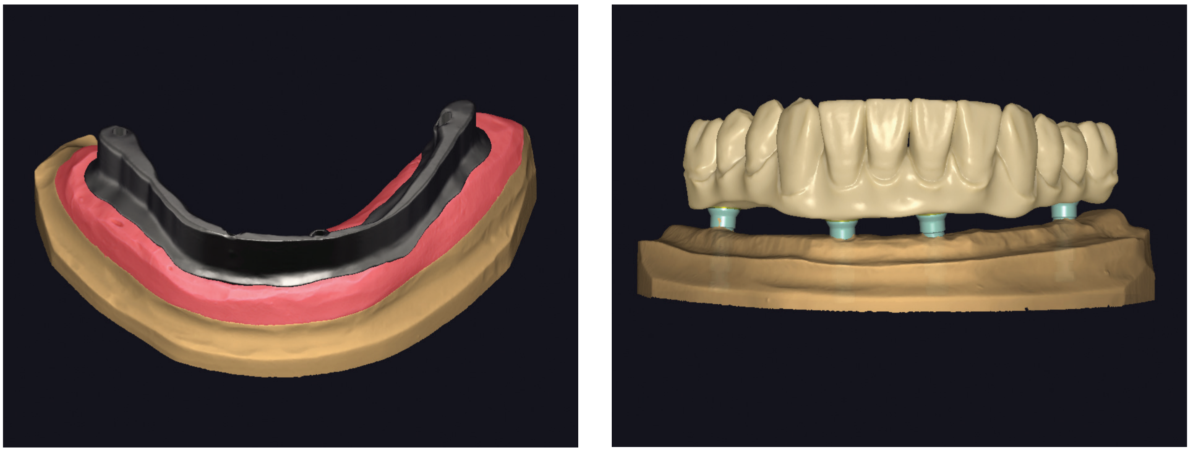

Figure 1. Based on CAD information, we can design and fabricate temporary and definitive prosthetic restorations on a metal bar.

Figure 2. Zirconia superstructure coupled to the titanium bar (Mdt Germano Rossi). In this case, the bar was made of grade 5 titanium Rematitan 5 (Dentaurum s.p.a) while zirconia Ceramotion Z Hybrid 1300/1020 Mpa (Dentaurum s.p.a) was chosen for the superstructure.

Figure 3. Case concluded: gingival and dental aesthetic ceramization with Ceramotion One Touch ceramic pastes (Dentaurum s.p.a).

long spans between adjacent implants and extend cantilevers. It also allows versatile use on different implant platforms, compensates for problems of unfavorable angles and offers the possibility, if necessary, to be segmented. The metal frameworks obtained by laser sintering/melting procedures have improved the “fit”, the “bonding” and the corrosion resistance compared to the bars obtained by casting[47]. Titanium is a suitable material due to its high tensile strength, fracture resistance, biocompatibility and low weight. The alternative is Cr-Co which has recently been re-evaluated in the implant-prosthetic field: it boasts a long experience of exposure in the oral cavity in removable partial prostheses, it is considered the first choice in the case of cantilevers or long spans, it is harder than titanium with improved scratch resistance and has great resistance to oxidation over time. Furthermore, in case of laser welding it guarantees excellent mechanical resistance[47,48]. The monolithic zirconia in this prosthetic design represents the first choice solution for reasons related to the intrinsic characteristics of the material and to the prosthetic technologies. From an aesthetic point of view, the metal framework gives the possibility to take full advantage of the new generations of translucent zirconia without risk of structural failure: only minimal ceramization of the gingival areas is necessary without resorting to vestibular cut-backs on the dental elements. The bar also makes it possible to simplify the clinical and technical management of the provisional and definitive prosthetic phases. Starting from the CAD design information on the bar, we can create PMMA provisionals that act as prototype prostheses useful in the preliminary evaluation and approval phase[2,33]. Information and any design updates of the provisional can be CAD converted and corrected in the zirconia prosthesis favoring a better physiological adaptation to the definitive restorations. The digital files allow the duplication of the temporary and definitive prosthetic restoration with immediate availability, ensuring easy management of all technical steps and all clinical complications. Monolithic zirconia can be cemented or screwed to the metal framework according to the clinician’s preferences, allowing for practicality and prosthetic retrievability. From an economic point of view, the hybrid metal-zirconia solution can be considered advantageous compared to pre-existing solutions. All traditional full-arch rehabilitation types, in fact, have various complications in the short and long term including: fracture or detachment of resin teeth, wear of occlusal surfaces, ceramic chipping, difficulty in color matching related to pink gingiva, lack passive fit, costly prosthetic repairs[49,50]. In particular, full-arch metal-acrylic implant-prosthetic restorations require five to six maintenance operations in 10 years with higher numbers in cases of bi-maxillary implant-prosthetic rehabilitation. In this sense, monolithic zirconia on a metal framework, despite higher initial costs than traditional solutions, is proposed over time as a less expensive prosthesis for the patient due to the characteristics of prosthetic recovery and the potential low rate of technical complications[31,49].

Conclusions

The introduction of monolithic zirconia for its characteristics of reliability and practicality has led to a downsizing in prosthetic design in implant prosthesis. The monolithic screw-retained design has encouraging success rates in the medium term but requires further in vitro and clinical studies for a more scientific analysis of the design criteria. Recent hybrid metal-zirconia solutions combine the advantages of two different materials such as monolithic zirconia and metal (Ti or Co-Cr as indicated) and appear to solve the limitations of screw-retained solutions. This innovative prosthetic implant design looks very promising. However, the long-term outcome of these implant-supported rehabilitations remains unknown due to the lack of sufficient clinical data.

Acknowledgments

The authors would like to thank Dentaurum Italia S.p.a. for supporting this article. We thank for the clinical case: Dr. Biagio Di Giuseppe, Roseto Degli Abruzzi (Te); Dr. Roberto Secchiaroli, Senigalia (An); Mdt Germano Rossi, Alba Adriatica (Te).

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