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Article

A multi-center retrospective assessment of monolithic zirconia restorations on posterior teeth and implants.

Una evaluación retrospectiva multicéntrica de restauraciones monolíticas de circonio en dientes posteriores e implantes.

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Abstract: Objective: the purpose of this multicenter retrospective study was to report on survival, success, and complication rates in monolithic zirconia restorations on teeth and implants. Materials and Methods: data on 671 monolithic zirconia restorations was collected by five prosthodontists from three different specialty practice centers, including a dental school and two private practice centers. Restorations included single crowns and multiple-unit fixed dental prostheses on teeth and implants in the posterior area (premolar and molars). Follow-up time was up to 62 months. Results: mean follow-up time was 28.1±12.9 months. A total of 671 units, 534 single crowns, and 137 multi-unit restorations. Cumulative survival and success rates at 5 years were 97.4%, and 93.8% respectively. Complications presented in 11 restorations out of 671 and included: decementation, abutment screw loosening, restoration crack, restoration fracture, and tooth fracture. No significant differences were observed between tooth-supported and implant-supported restoration (p=0.42), single crowns and multiple-unit restorations (p=0.07), bruxers and non-bruxers (p=0.57). Patients with group function occlusal scheme had significantly less survival rates (p=0.001). Conclusion: the use of monolithic zirconia for restorations on the posterior teeth and implants seems to be promising as it provides a durable solution with a low rate of complications.

Keywords: Zirconium dioxide; dental implants; crowns; tooth fractures; dental prosthesis; implant-supported.

Resumen: Objetivo: el propósito de este estudio retrospectivo multicéntrico fue informar sobre las tasas de supervivencia, éxito y complicaciones en restauraciones monolíticas de circonio en dientes e implantes. Materiales y Métodos: cinco prostodoncistas recolectaron datos de 671 restauraciones monolíticas de zirconia de tres centros de práctica especializados: una escuela de odontología y dos centros de práctica privados. Las restauraciones incluyeron coronas individuales y prótesis dentales fijas de unidades múltiples en dientes e implantes en el área posterior (premolares y molares). El tiempo de seguimiento fue de hasta 62 meses. Resultados: el tiempo medio de seguimiento fue de 28,1±12,9 meses. Un total de 671 unidades, 534 coronas individuales y 137 restauraciones de unidades múltiples. La supervivencia acumulada y las tasas de éxito a los 5 años fueron del 97,4% y del 93,8%, respectivamente. Las complicaciones se presentaron en 11 restauraciones de 671 e incluyeron: fracaso del cementado, aflojamiento del tornillo del pilar, grieta en la restauración, fractura de restauración y fractura de dientes. No se observaron diferencias significativas entre la restauración con soporte dental y con implante (p=0,42), coronas individuales y restauraciones de unidades múltiples (p=0,07), pacientes con bruxismo y sin bruxismo (p=0,57). Los pacientes con esquema oclusal de función grupal tuvieron tasas de supervivencia significativamente menores (p=0,001). Conclusión: el uso de zirconia monolítica para restauraciones en los dientes posteriores y en implantes parece ser prometedor, ya que proporciona una solución duradera con una baja tasa de complicaciones.

Palabras Clave: *Zirconia; implantes dentales; coronas; fracturas de los dientes; prótesis dental de soporte implantado.*

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INTRODUCTION.

Material selection for fabrication of dental prostheses has become imperative to our clinical practice with an increasing number of patients that request metal-free restorations and the growing choices of metal-free restorative materials. Therefore, the search for a material that offers biocompatibility, esthetics, and good mechanical properties remains a challenge for the clinicians. In recent years, zirconium dioxide (Zirconia) has been widely used in fixed prostheses due to its superior physical properties[1-3] as well as biocompatibility.[4,5]

Due to its high opacity, esthetics improvement is usually performed by using zirconia as a framework with porcelain layering to enhance translucency. However, fracture of the veneering porcelain has always been a major concern in tooth-supported as well as implant-supported zirconia-based restorations.[6-9] In an attempt to reduce chipping and still get an acceptable esthetic result, avoiding ceramic veneers in high-stress areas and limiting the use of it on the labial surfaces and the non-load bearing areas has been applied and used. The annulment of having dissimilar layers of zirconia and veneering porcelain has become possible only recently, through manufacturing third generation more translucent zirconia, in combination with CAD/CAM which enabled its monolithic (full-contour, anatomic) application. In addition, elimination of the veneering layer has other advantage as it enables the manufacture of thin, thus less invasive, restorations.[5,8,10]

Regrettably, few clinical studies are available on the performance of monolithic and partially veneered zirconia restorations, with most of them being on full arch implant –supported fixed prostheses.[10-12]

The purpose of this multicenter retrospective clinical study was to evaluate the clinical outcome of full-contour monolithic Zirconia: tooth-supported and implant-supported, single crowns and multiple unit FDPs in the posterior areas (premolars and molars) on the basis of survival and success rate and incidence of complications in restorations.

MATERIALS AND METHODS.

This multi-center retrospective study was conducted in three centers including a dental school and two private practice centers. The inclusion criteria for the present study were: age more than 18 years, good periodontal status, and in need for a single crown or multi-unit FDP in the posterior region (premolars and molars) whether on teeth or implants. Presence of opposing dentition and at least one adjacent tooth was mandatory as well. Study included restorations that were placed between November 2012 and December 2017 and had at least one-follow up visit by April 2018. The indications for the restorations on natural teeth varied including root canal treated teeth with large fillings requiring full coverage restorations, deep cracks, fractured teeth and severe attrition. For natural teeth, the preparation design was completed according to the generally recommended guidelines for zirconia which is chamfer margin with 1.5mm occlusal reduction and axial reduction of at least 0.5mm. Conventional addition silicone impressions (3M ESPE Dental Supplies, Germany) were obtained after proper soft tissue management and retraction around natural teeth.

The poured stone models were scanned by a bench top extra-oral scanner (IMES-ICORE GmbH, Germany), restorations were designed and machined from monolithic zirconia blocks (Whitepeaks Dental Solutions GmbH, Germany) with a Computer Aided Manufacturing (CAM) (Cercon brain, Dentsply Sirona K.K.) milling procedure. After the milling procedure, the restorations were sintered at 1,550°C for 12hr, and the sintered restorations were glazed at 920°C for 15min.

When the restorations were ready for delivery, the provisional restorations were removed for intraoral try-in. Restorations were checked for marginal fit, inter-proximal contacts and occlusion. Minor adjustments were performed using EVE Diacera Twist polishers (ERNST VETTER GmbH, Germany), if necessary. Final extraoral polishing procedures were performed with solid polish (Zircon Bite, Dental Ventures of America Inc., Corona, CA, USA). Cement-retained restorations were mostly cemented with a resin modified glass ionomer cement (RelyX™ Luting Plus Cement) or self-etch, dual-cure, composite cement system (RelyX™ Unicem Self-Adhesive Universal Resin Cement, or a glass ionomer cement (Ketac™ Cem Permanent Glass Ionomer Luting Cement) and some of the implant supported restorations were cemented using a temporary cement (or GI, or RMGI or temp bond, Kerr Dental, Switzerland|). For screw-retained implant restorations, they were torqued

according to implant-manufacturer instructions and screw access holes were covered with composite fillings after placing Teflon tape.

Clinical follow-up assessment was performed by the 5 participating prosthodontists at follow up visits. Demographics (age, sex), prosthetic treatment records, and outcomes of the monolithic Zirconia restorations were ascertained during chart review. Clinical data included time in function and complications. Nature of complications and point of time at which they happened were recorded.

Statistical analysis

Statistical analysis was performed using SPSS Statistics 23 (IBM; Armonk, NY). Descriptivestatistics were reported. Success and survival rates were computed using theKaplan-Meier analysis. According to Pjetursson *et al.*,[13] Success was defined as the reconstruction that remained unchanged and did not require any intervention during the entire observation period. Survival was defined as the reconstruction remaining *in situ* with or without modification over the observation period.

Table 1. Distribution of numbers and percentages for different categories of restorations.

Tooth- supported 418.62.3%				**Implant- supported 253.37.7%**							
Single crowns		FPDs		Single crowns		FPDs		Cement-retained		Screw-retained	
n	%	n	%	n	%	n	%	n	%	n	%
407	97.4	11	2.6	127	50.2	126	49.8	150	59.3	103	40.7

Table 2. Summary of survival and success rates for different categories of restorations at 60 months.

	Survival rate at 62 months	**Success rate at 62 months**
Over all	97.3 %	93.8 %
Single crowns	96.6 %	92.9 %
Multi-unit restorations	100 %	99 %
Tooth-supported restorations	96.6 %	94.1 %
Implant-supported restorations	98.3 %	94 %
Single crowns on teeth	96.5 %	94 %
Multi-unit restorations on teeth	100 %	100 %
Single crowns on implants	96.5 %	89.5 %
Multi-unit restorations on implants	100 %	98 %

Table 3. Summary of types and frequencies of complications encountered.

Complication	**tooth number**	**Time at which complication happened (months)**	**Frequency (total)**	**Frequency in single crown tooth-supported restoration**	**Frequency in multiple unit tooth- supported restoration**	**Frequency in single crown implant-supported restorations**	**Frequency in multi-unit implant-supported restoration**
Crack	Tooth #3	1					
	Tooth #30	6	2	1		1	
Decementation	Tooth #31	15					
	Tooth #31	20					
	FDP, teeth # 2-4	18	4		1	3	
	Tooth #13	22					
Restoration fracture	Tooth #13	19	1	1			
Tooth fracture	Tooth #12	14	1	1			
Abutment screw-loosening	Tooth #13	15	3			3 (1 screw-	
	Tooth #19	13				retained, and	
	Tooth #31	3				2 cement-retained)	
Total			11				

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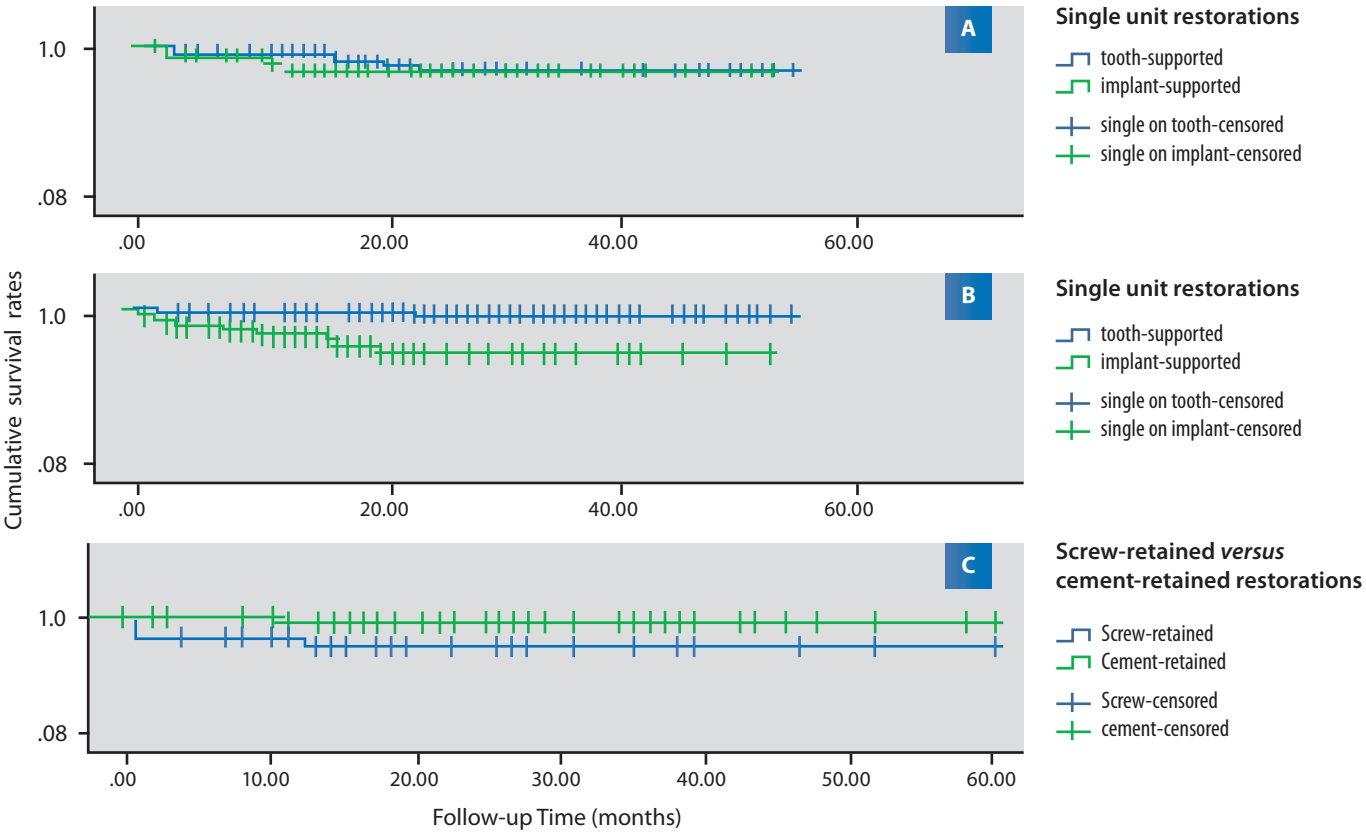
Figure 1. Cumulative survival rates.



A. Single unit tooth-supported (96.5%) *versus* single unit implant-supported (96.5%), up to 62 months, showing identical survival rates for both groups. **B.** Canine guidance (99.3%) *versus* group function (94.3%) occlusal schemes up to 62 months, showing significant less survival rate (p= 0.001) in the group function occlusal scheme cases. **C.** Screw-retained (96.2%) versus cement-retained (99.2%), up to 62 months, showing slightly higher survival rate for cement-retained restorations.

RESULTS.

A total of 235 patients (63 males, 172 females; mean age 44.8±13.6 years). A total of 671 units, 533 single crowns, and 138 multi-unit restorations units on 92 abutments were included. The range of follow up period was from 6 to 62 months. Mean duration of follow-up was 28.1±12.9 months. The distribution of monolithic zirconia restorations. (Table 1)

According to Log Rank (Mantel-Cox) Chi square test associated with kaplan Meier analysis, there were no significant differences in survival rate between single and multiple units (p=0.07), tooth *versus* implant-supported restorations (p=0.42), single crowns on teeth *versus* single crowns on implants (p=0.72) with a survival rate of 96.5% for both types of restorations at 62 months, (Figure 1A) and bruxers vs. non-bruxers (p=0.57). However, the incidence of complications was higher in bruxers with a survival rate of 97.1% compared to 98.8% for non-bruxers at 62 months.

There was a statistically significant difference in survival rate according to occlusal scheme (p=0.001), with higher incidence of complications in subjects with group function occlusal scheme, as the survival rate in canine guidance group was 99.3% as opposed to 94.3% for the group function occlusal scheme group at 62 months. (Figure 1B) As for cement *versus* screw-retained implant-sup-ported restorations, there was no significant difference (p=0.17), with a survival rate of 99.2% cement-retained and 96.9% for screw-retained restorations at 62 months. (Figure 1C)

As for the number of restoration units that were in situ between 40-62 months at time of review, they constituted 236 out of the 671 units (35%), of which 148 units were in situ for 50-62 months at the time of review. The cumulative survival rate was 97.3% at 5 years, while the success rate was 93.8% at 5 years. Survival and success rates for different types of restorations. (Table 2)

A summary of complications that occurred. (Table 3)

DISCUSSION.

The introduction of computer-aided design and computer-aided manufacturing of all-ceramic restorations provided new approaches for addressing restorative challenges. Despite Zirconia's excellent phy-sical properties and its wide use as abutment, as well as framework material for implant-borne crowns and fixed dental prostheses, veneering porcelain chipping has been identified as the major technical complication.[14-16]

In a systematic analysis of zirconia-based FDPs by Schley *et al.,*[17] a survival rate of 94.3% was reported. However, when technical complications such as chipping of the veneering ceramic were included, their survival decreased to 76.4%. Heintze *et al.,*[1] performed a systematic review to analyze the survival of layered Zirconia (90%) and metal 97% supported FDPs after three years.

Sax *et al.,*[18] reported a mean long-term survival rate of Zirconia frameworks at 10 years to be 91.5% with failures attributed to marginal deficiencies and veneer chipping.

The clinical performance of monolithic zirconia for tooth and implant-supported single and multi-unit restorations other than full arch restorations is currently not well documented in the dental literature. Regarding implant-supported SCs, there is a scarcity of studies investigating the clinical outcomes of monolithic or modified (minimally layered on the labial surface only) monolithic zirconia implant-supported SCs.[7, 10]

Most of the available studies report on the modified monolithic design with veneering porcelain limited to the buccal surface to obtain improved satisfactory esthetic results.[11,19-22] As for single full-arch implant rehabilitation, a case series with 17 edentulous mandibles restored with monolithic zirconia one-piece FDPs opposing complete dentures reported favorable 1-year outcomes. One of 17 monolithic zirconia full- arch FDPs failed due to framework fracture.[21] A retrospective analysis of 26 full-arch implant-supported zirconia prostheses with modified monolithic design observed that only three porcelain veneered teeth had minor cohesive porcelain fracture, with a prosthesis success rate of 94.8%.[22] In regard to dual-arch implant rehabilitation with monolithic zirconia, few clinical reports with 6-24 month follow- up periods reported satisfactory outcomes.[11,20]

A review by Spitznagel *et al.,*[23] showed that the use of monolithic lithium disilicate and zirconia for implant-supported single crowns and fixed prosthodontics was effective and reliable in short-term studies. Our study is reporting on a total of 671 monolithic zirconia restoration units for a follow up period of up to 62 months. From our results, the success and survival rates seem promising with no significant differences between tooth and implant-supported, single and multi-unit restorations and even bruxing habit presence.

However, bruxers tended to have slightly higher rate of complications. Nevertheless, it was not a significant difference. On the other hand, there was a significant higher chance for complications in individuals that presented with group function occlusal scheme. This is in accordance with other studies that looked into occlusal scheme and occlusal forces distribution effect on long term complications in other types of restorations.[24,25]

One of the main concerns about using monolithic Zirconia against natural teeth is the unknown effect of abrasiveness. An *in vitro* study showed that monolithic Zirconia and composite resin resulted in less wear depth to human enamel comparable to glass ceramic and enamel.[26] In a clinical observation study,[27] it was reported that after 2 years, wear of opposed enamel caused by monolithic zirconia crowns was approximately twice that caused by natural teeth. However, other studies that evaluated wear caused by monolithic zirconia as well as other ceramic and porcelain fused to metal restorations have shown similar wear amount to the opposing natural teeth among those different types of restorations.[28-30]

Therefore, the use of monolithic zirconia crowns can be recommended taking into consideration that more studies of a prospective nature and longer follow up times are needed to confirm the long-term effectiveness of this type of restorations as far as survival rates and expected complications.

CONCLUSION.

According to the results of this retrospective study, the choice of monolithic Zirconia for the posterior tooth-supported and implant-supported restorations seems to be a valid treatment option. Further long-term prospective studies are needed to confirm the results presented in this study.

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