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Clinical risk factors related to failures with zirconia-based restorations: An up to 9-year retrospective study

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ABSTRACT

Objectives: The first objective of this study was to retrospectively evaluate zirconia-based restorations (ZBR). The second was to correlate failures with clinical parameters and to identify and to analyse chipping failures using fractographic analysis.

Methods: 147 ZBR (tooth- and implant-supported crowns and fixed partial dentures (FPDs)) were evaluated after a mean observation period of 41.5 ± 31.8 months. Accessorily, zirconia implant abutments ($n = 46$) were also observed. The technical (USPHS criteria) and the biological outcomes of the ZBR were evaluated. Occlusal risk factors were examined: occlusal relationships, parafunctional habits, and the presence of occlusal nightguard. SEM fractographic analysis was performed using the intra-oral replica technique.

Results: The survival rate of crowns and FPDs was 93.2%, the success rate was 81.63% and the 9-year Kaplan–Meier estimated success rate was 52.66%. The chipping rate was 15% and the framework fracture rate was 2.7%. Most fractographic analyses revealed that veneer fractures originated from occlusal surface roughness. Several parameters were shown to significantly influence veneer fracture: the absence of occlusal nightguard ($p = 0.0048$), the presence of a ceramic restoration as an antagonist ($p = 0.013$), the presence of parafunctional activity ($p = 0.018$), and the presence of implants as support ($p = 0.026$). The implant abutments success rate was 100%.

Conclusions: The results of the present study confirm that chipping is the first cause of ZBR failure. They also underline the importance of clinical parameters in regards to the explanation of this complex problem. This issue should be considered in future prospective clinical studies.

Clinical significance: Practitioners can reduce chipping failures by taking into account several risk parameters, such as the presence of a ceramic restoration as an antagonist, the presence of parafunctional activity and the presence of implants as support. The use of an occlusal nightguard can also decrease failure rate.

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1. Introduction

In prosthodontics, porcelain-fused-to-metal (PFM) restorations have passed the test of time and are recognized as predictable and reliable clinical solutions for fixed prostheses. Nevertheless, since the eighties, the increasing aesthetic demand in dentistry has driven the development of various ceramic core materials. Introduced a decade ago as an alternative to metal, yttria-tetragonal zirconia polycrystal (Y-TZP) exhibits transformation-toughening properties, which give it high strength and tenacity in comparison with other ceramic core material.[1] Unfortunately, despite Y-TZP frameworks mechanical properties, clinical reports about zirconia-based crowns and fixed partial dentures (FPDs) have indicated a high rate of short-term failures, which are related to cohesive fracture of the veneering ceramic (chipping). In the systematic review of Schley et al.,[2] the mean estimated 5-year survival rate for FPDs was 94.3%, while the 5-year complication free rate was only 76.4%. Chipping is the most frequent technical complication and is reported to be significantly higher than for PFM restorations.[3–5] The short-term crowns and FPD chipping rate varies from 0 to 88.9%, the weighted (by sample size) average of 32 studies being 12.3% (Table 1),[4–35] while a 2.9% chipping rate is reported for PFM restorations.[2,36–38] Some studies distinguish minor chipping, which can be simply polished and does not require removal from the restoration, from major chipping and delaminations. However delaminations, which imply a fracture at the interface between veneer and zirconia, are not easy to diagnose intra-orally, since high magnification observation is required to confirm the interfacial rupture and the framework exposition. In 2007, Anusavice et al. pointed out the necessity to standardize the diagnosis of veneer fracture, but today this is still lacking even with PFM restorations, as well as the analysis of this type of clinical failure.[39] The authors particularly recommended the development of a comprehensive classification system for identifying failures and the utilization of fractographic analysis to identify the fracture origin. The same year, Scherrer et al.[40] demonstrated the benefit of the replica technic for the fractographic analysis of failed ceramic restorations. This technic allows the identification of the crack's origin and its direction of propagation, analysing fractographic markers such as hackle lines, arrest lines or wake hackles on an epoxy replica of the restoration.

The chipping mechanism is complex and not well understood in such complex geometries as dental crowns and bridges. Numerous in vitro studies about fracture strength, crack propagation, and veneer-zirconia adhesion have been published. But there are both advantages and limitations to flexure, tensile and shear tests. These tests are particularly not easy to interpret and a lack of standardized procedures has been described.[39] Moreover, the source of cracks in dental

Table 1 – List of clinical trials conducted in Y-TZP-based restorations.

Study	Follow-up period (years)	Sample size	Veneering porcelain fracture (%)
Larsson et al. (2013)[6]	8	9	88.9
Rinke et al. (2013)[7]	7	80	28.8
Zembic et al. (2012)[8]	5.6	18	0
Ortorp et al. (2012)[9]	5	143	3
Vigolo et al. (2012)[5]	5	39	7.7
Lops et al. (2013)[10]	5	37	10.8
Burke et al. (2013)[11]	5	33	24.2
Sailer et al. (2007)[12]	5	33	15
Schmitter et al. (2012)[13]	5	30	26.7
Schmitt et al. (2012)[14]	5	25	28
Molin and Karlsson (2008)[15]	5	19	0
Sagirkaya et al. (2012)[16]	4	107	0.9
Peláez et al. (2012)[4]	4	20	10
Salido et al. (2012)[17]	4	17	29.1
Beuer et al. (2010)[18]	3	68	7.4
Tinschert et al. (2008)[19]	3	65	6
Rinke et al. (2013)[20]	3	52	5.8
Sailer et al. (2009)[21]	3	36	33.4
Edelhoff et al. (2008)[22]	3	21	9.5
Beuer et al. (2009)[23]	3	21	0
Schmitt et al. (2010)[24]	3	17	5.9
Papaspyridakos et al. (2012)[25]	3	16	31.3
Raigrodski et al. (2006)[26]	2.5	20	25
Pospiech et al. (2003)[27]	2	38	2.6
Esquivel-Upshaw et al. (2013)[28]	2	36	16.7
Vult Von Steyern et al. (2005)[29]	2	20	15
Tsumita et al. (2010)[30]	2	21	14.3
Cehreli et al. (2009)[31]	2	15	0
Ohlmann et al. (2012)[32]	2	10	20
Bornemann et al. (2003)[33]	1.5	59	3.3
Ohlmann et al. (2008)[34]	1	30	13
Larsson et al. (2006)[35]	1	13	54
Weighted (by sample size) average			12.3