3M Science. Applied to Life.™

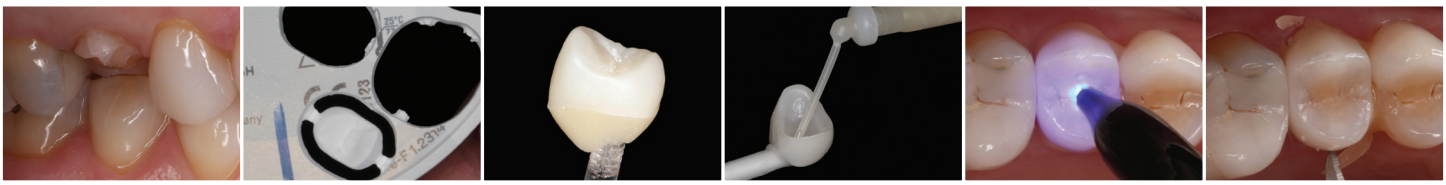
3M℠ Health Care Academy

A hidden secret for successful clinical outcomes.

Numerous Clinical Studies Demonstrate the Efficacy of Cementing 3M™ Lava™ Zirconia Restorations with 3M™ RelyX™ Unicem Self-Adhesive Resin Cement

Dr. Carola Carrera, DDS, PhD
3M Research Specialist

Geoffrey Morris, PE
3M Scientific Affairs Manager



Clinical dentistry and photography by David Hornbrook, DDS, FAACD
Restorations by Utah Valley Dental Lab

Background

Secondary caries are the most common cause for restoration failure and replacement[1], placing a tremendous burden on the health care system. In addition, the diagnosis and treatment of secondary caries often involve further tooth destruction and weakening of the remaining structure. For these reasons, technologies that minimize or eliminate the root causes are of significant importance. Dysbiotic oral biofilms (oral bacteria) are the main drivers of secondary caries. In the presence of favorable conditions – including the presence of interfacial failure (gaps), poor diet and poor oral hygiene – oral biofilms can thrive and colonize the interface between the restoration and the tooth margin, leading to tooth demineralization and secondary caries formation. Preventing these bacteria from physically finding their way underneath a restoration is therefore considered a strategic method for avoiding secondary caries.

One method of sealing the restoration against bacterial invasion is to engineer the dimensional tolerances of the material such that it mates or fits perfectly to the tooth preparation with no gap at the margin. Significant advances have been made in the ability to manufacture tight fitting restorations, however, a perfect fit is rarely achieved and therefore dental cements are used to fill any gaps that are present.

Dental cements must be engineered to prevent the advance of bacteria even after repeated mechanical loading and thermal cycling events. In addition the cement must be sufficiently inert in the oral environment and not wash out over time.

Materials

3M™ Lava™ Zirconia was introduced commercially more than 15 years ago as an esthetic alternative to metal for crown and bridge restorations. It utilizes computer aided design (CAD) and computer aided manufacturing (CAM) to produce zirconia restorations. A basic process flow diagram for the fabrication of a Lava zirconia restoration is given in the figure below.

The ability to predict and uniformly control the shrinkage that occurs during the sintering step was a key design challenge for the ceramic engineers involved with the development of Lava zirconia. If the shrinkage varied or was unpredictable the finished restorations would have poor fit. In vitro studies were performed to determine the accuracy of Lava zirconia restorations with marginal gaps on the order of 25 µm measured[3,4].

3M™ RelyX™ Unicem Self-Adhesive Resin Cement is engineered to be a self-adhesive resin cement with low solubility in the oral environment and appropriate mechanical strength and bonding capability to both the tooth preparation and zirconia ceramics[5]. The combination of the accurate fit of Lava zirconia restorations combined with RelyX Unicem cement should seal the restoration against bacterial invasion with the benefit of a low frequency of secondary caries.

The ultimate test however is the clinical performance of the system. Numerous studies have now been conducted to determine all failure modes with zirconia restorations including the occurrence of secondary caries. This specific response was measured in most studies as it is an indirect way to validate the dimensional accuracy of the CAD/CAM manufacturing process.

Clinical Results and Discussion

Two overview articles[6,7] have been published on the survival rates of multi-unit zirconia based restorations which are considered the most challenging with regard to fit and fidelity. The references cited in these articles were evaluated with regard to the occurrence of secondary caries as assessed by the investigators using various methods. Details can be found in the cited references. The studies found are compiled in the table below and include only those articles in peer reviewed journals.

Conclusions

The studies highlighted with bold type discuss restorations with durations greater than two years. No studies were found which showed the presence of secondary caries when 3M™ Lava™ Zirconia Restorative was used in combination with 3M™ RelyX™ Unicem Self-Adhesive Resin Cement.

Author	Restorative Material	Cement	Study Length (Months)	# of Restorations Initial/Recall	Secondary Caries
Christensen[8]	3M™ Lava™ Zirconia Restorative	3M™ RelyX™ Luting Plus Resin Modified Glass Ionomer Cement	36	293/190	3%
Zenthofer[9]	**3M™ Lava™ Zirconia Restorative**	**3M™ RelyX™ Unicem Aplicap™/ Maxicap™, or Clicker™ Cement**	**36**	**21/19**	**No secondary caries observed**
Gherlone[10]	**3M™ Lava™ Zirconia Restorative**	**3M™ RelyX™ Unicem Aplicap™/ Maxicap™, or Clicker™ Cement**	**36**	**86/60**	**No secondary caries observed**
Tinschert[11]	Precident DCS Zirconia	Harvard Zinc Phosphate (posterior), Panavia 21 (anterior)	38	65/58	No secondary caries observed
Beuer[12]	Cercon Zirconia	3M™ Ketac™ Cem Aplicap™ Glass Ionomer Luting Cement	40	21/21	No secondary caries observed
Sagirkaya[13]	Various (Lava, ZirkonZahn, Katana)	Panavia F 2.0	48	267/267	No secondary caries observed
Roediger[14]	Cercon Zirconia	Harvard Zinc Phosphate	48	99/91	3%
Palaez[15]	**3M™ Lava™ Zirconia Restorative**	**3M™ RelyX™ Unicem Aplicap™/ Maxicap™, or Clicker™ Cement**	**48**	**20/20**	**No secondary caries observed**
Molin[16]	Denzir CAD Zirconia	De Trey Zinc Phosphate, Panavia F	60	19/19	No secondary caries observed
Sorrentino[17]	Procera Zirconia	3M™ RelyX™ Unicem Self-Adhesive Resin Cement	60	48/48	No secondary caries observed
Schmitt[18]	3M™ Lava™ Zirconia Restorative	3M™ Ketac™ Cem Glass Ionomer Luting Cement	60	25/20	No secondary caries observed
Raigrodski[19]	3M™ Lava™ Zirconia Restorative	3M™ RelyX™ Luting Plus Resin Modified Glass Ionomer Cement	60	20/18	No secondary caries observed
Burke[20]	**3M™ Lava™ Zirconia Restorative**	**3M™ RelyX™ Unicem Aplicap™/ Maxicap™, or Clicker™ Cement**	**60**	**41/33**	**No secondary caries observed**
Rinke[21]	Cercon Zirconia	Harvard Zinc Phosphate	84	99/80	7%
Sola-Ruiz[22]	3M™ Lava™ Zirconia Restorative	Multilink	84	27/27	7%

References:

1. Jokstad, A. (2016). Secondary caries and microleakage, *Dental Materials* (32), 11-25.
2. Summitt, J.B., et al, (2006) Fundamentals of operative dentistry a contemporary approach, third edition, Chicago, Ill: Quintessence Publishing Co, Inc.
3. Karatasli, O., et al, (2011) Comparison of the marginal fit of different coping materials and designs produced by computer aided manufacturing systems, *Dental Materials Journal* 30 (1), 97-102.
4. Shannon, A., et al, In-Vitro Vertical Marginal Gap Comparison of CAD/CAM Zirconium Copings, J Dent Res Vol# 86 (Spec Iss A): 828 (2007).
5. Cetik, S., et al, (2016) In Vitro Study of the Sealing Ability of Cements for Zirconia Restorations, *Journal of Prosthodontics* (00), 1–8.
6. Pjetursson, B., et al, (2015) All-ceramic or metal-ceramic tooth supported fixed dental prostheses (FDPs)? A systemic review of the survival and complication rates. Part II: Multiple-unit FDPs, Dental Materials (31), 624-639.
7. Raigrodski, A., (2012) Survival and complications of zirconia-based fixed dental prostheses: A systematic review, *The Journal of Prosthetic Dentistry* 107 (3), 170-177.
8. Christensen, R., (2010) A clinical comparison of zirconia, metal and alumina fixed-prosthesis frameworks veneered with layered or pressed ceramic a three-year report, *Journal of American Dental Association* 141 (11), 1317-1329.
9. Zenthofer, A., et al, (2015) Performance of zirconia ceramic cantilever fixed dental prostheses: 3-year results from a prospective, randomized, controlled pilot study, *The Journal of Prosthetic Dentistry* 114(1): 34-38.
10. Gherlone, E., et al, (2014) A 3 years retrospective study of survival for zirconia-based single crowns fabricated from intraoral digital impressions, *Journal of Dentistry* 42: 1151-1155.
11. Tinschert, J., et al, (2008) Clinical behavior of zirconia-based fixed partial dentures made of DC-Zirkon: 3-Year Results, *International Journal of Prosthodontics*, 21 (3), 217-222.
12. Beuer, F., et al, (2009) Three-year clinical prospective evaluation of zirconia-based posterior fixed dental prostheses (FDPs), *Clin Oral Invest* 13, 445-451.
13. Sagirkaya, E., et al, (2012) A Randomized, prospective, open-ended clinical trial of zirconia fixed partial dentures on teeth and implants: interim results, *International Journal of Prosthodontics 25* (3), 221-231.
14. Roediger, M., et al, (2010) Prospective evaluation of zirconia posterior fixed partial dentures: four-year clinical results, *International Journal of Prosthodontics* 23 (2),141-148.
15. Pelaez, J., et al, (2012) A four-year prospective clinical evaluation of zirconia and metal-ceramic posterior fixed partial dental prostheses, *The International Journal of Prosthodontics* 25(5): 451-458.
16. Molin, M., et al, (2008) Five-year clinical prospective evaluation of zirconia-based Denzir 3-Unit FPDs, *International Journal of Prosthodontics* 21(3), 223-227.
17. Sorrentino, R., et al, (2012) Five-year prospective clinical study of posterior three-unit zirconia-based fixed dental prostheses, *Clin Oral Invest* 16, 997-985.
18. Schmitt, J., et al, (2012) Zirconia posterior fixed partial dentures: 5-year clinical results of a prospective clinical trial, *International Journal of Prosthodontics* 25 (6), 585-589.
19. Raigrodski, A., et al, (2012) Clinical efficacy of veneered zirconium dioxide-based posterior partial fixed dental prostheses: Five-year results, *Journal of Prosthetic Dentistry* 108(4), 214-222.
20. Burke, F., et al, (2013) Five-year clinical evaluation of zirconia-based bridges in patients in UK general dental practices, *Journal of Dentistry* 41: 992-999.
21. Rinke, S., et al, (2013) Prospective evaluation of zirconia posterior fixed partial dentures: 7-year clinical results, *International Journal of Prosthodontics* 26 (2) 164-171.
22. Sola-Ruiz, M., et al, (2015) A prospective evaluation of zirconia anterior partial fixed dental prostheses: Clinical results after seven years, *Journal of Prosthetic Dentistry* 113 (6), 578-584.

Dr. Carrera received her DDS and specialty in prosthodontics from University of Talca, Chile in 2003 and 2008, respectively. Upon completing her dental training, she was hired as an adjunct professor at the University of Talca, Chile and later promoted to assistant professor. From 2003 to 2011 she coordinated and instructed several courses including Dental Pre-Clinic, Dental Materials, Restorative Fundamentals and Cariology, among others. During this time, she also maintained a local clinical dental practice. In 2011, she joined the PhD program in Oral Biology at the University of Minnesota. Her research focused on interactions between oral biofilms and dental composite restorations. Dr. Carrera received her PhD from the University of Minnesota in May 2016. She currently works as a research specialist in 3M Oral Care Solutions Division.

Geoffrey Morris, PE has more than 30 years experience in product development with a combined 10 in the oral care industry (3M Dental Products Division and 3M Unitek). His time in the 3M Oral Care Division focused on the development of direct restoratives materials during which he gained a deep knowledge and understanding of clinical research methodologies. He holds a Bachelor's degree in Ceramic Engineering from the Georgia Institute of Technology and a Master of Science degree in Ceramic Engineering from the University of Illinois in Urbana-Champaign, USA. In 2015, Geoffrey Morris was inducted into Georgia Tech's Academy of Distinguished Engineering Alumni. He is licensed to practice engineering and is currently registered in the State of Minnesota.

3M Oral Care
2510 Conway Avenue
St. Paul, MN 55144-1000
USA
1-800-634-2249

3M Canada
Post Office Box 5757
London, Ontario N6A 4T1
Canada
1-888-363-3685

3M.com/Dental