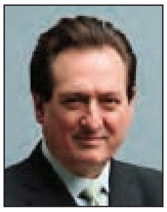
A New Paradigm For Creating Durable Occlusal Precision With Indirect Bondable Ceramic

Un nouveau paradigme pour créer une occlusion durable et précise, avec une technique indirecte pour céramique mordancée.



Dr. Dennis P.A. Nimchuk, DDS, FRCD(C), FCDS(BC)

Abstract

The current development of high composition Lithium Disilicate ceramic for dental use has enabled clinical dentists to utilize complete or partial crowns that fulfill the restorative requirements of: accurate marginal fit, high fracture toughness, low abrasion, low thermal conductivity, high esthetics, adhesive luting, and when used in the press form utilizing lost-wax technique, also, occlusal precision. For the restorative Dentist who has relied on a gold occlusion for occlusal accuracy, e.max press is an alternative that provides significant additional benefits. At this time longer clinical performance evaluations are required to validate this material and to provide evidence for success in extended in vivo service.

Introduction

When diagnosed and executed properly, the clinical service of a well-prepared, well-constructed, and well-finished cast gold restoration can and has historically exceeded the precision and longevity of all other tooth-colored materials, direct or indirect, composite or ceramic.1-5

Notwithstanding, since the Weinstein patent of 1959 6, porcelain fused to metal has become the preferred choice for complete crown restorations principally because of the ability of porcelain to mimic the esthetic appearance of dental enamel. PFM's have reliably served the dental profession for over half a century providing restorations that for the most part are strong and esthetic. However, the PFM systems have never been able to achieve the occlusal precision or the service integrity that cast gold has provided.

Other high strength cores, made from ceramic instead of metal have also been available for considerable time. Core materials such as aluminum oxide and stabilized zirconia while very fracture resistant and more esthetic than metal, have not been esthetic enough on their own to be an acceptable substitute to metal or metal based ceramics. They have however allowed for a hybrid layering of more esthetic ceramic veneers. Unfortunately, like PFM systems, these layered hybrids have also not been able to achieve the occlusal precision or the service integrity that cast gold has provided and have been prone to ceramic fracture and chipping.

Presently, however, ceramic systems created of pressed or CAD lithium disilicate, (IPS e.max), have evolved to deliver all of the desired elements for an optimum restoration: precision, strength, retention, esthetics, comfort and abrasion compatibility. These newer, bondable monolithic restorations seem to be able to rival and even surpass the qualities of cast gold when used as a single unit of restoration.

About Lithium Disilicate

In dentistry glass ceramics are defined according to their major crystalline structure and/or application. Lithium disilicate is among the best known and most widely used among all the types of glass ceramics. The composition of IPS e. max lithium disilicate, includes quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and

Résumé

Le développement actuel de céramique composée principalement de Disilicate de Lithium en art dentaire, a permis aux dentistes d'obtenir des couronnes complètes ou partielles qui respectent les exigences restauratrices suivantes: ajustement précis à l'épaulement, haute résistance à la fracture, peu d'usure, minimum de conductivité thermale, excellentes esthétiques, bonne adhésion du ciment, et lorsque fabriquées avec la technique de la cire perdue et de presse, également parfaite occlusion. Pour le dentiste en restauration, qui a toujours compté sur une occlusion en or, pour une occlusion précise, la presse e.max est une alternative qui apporte des bénéfices additionnels considérables. À cet effet, des évaluations de performance cliniques seront nécessaires pour valider ce matériau, et pour apporter une évidence de succès dans un service in vivo prolongé.

traces of additional other components 7. This composition, where lithium disilicate is incorporated at around the 70 percentile, is capable of producing a highly thermal shock resistant glass ceramic due to the low and even thermal expansion that results when it is processed. The material on completion becomes very resistant to developing micro-cracks or fracture during cooling and from post-production stresses placed on it and when making grinding adjustments or aggressive heat induced polishing. At in vivo function and in parafunction it is also extremely fracture resistant (Fig. 1).

Restorations made from this type of glass ceramic can be processed utilizing familiar, lost-wax, hot pressing techniques or by utilizing contemporary, state-of-the-art, CAD/CAD milling procedures 8. Because it is not a powder liquid build-up technique there is not the extensive condensing shrinkage of the material during the three or more furnace firing phases. which in aggregate can amount to 25 percent of the original stacked volume 9 – 10 - 11

About Porcelain Fused to Metal

The prevalence of ceramic fractures in the dental industry is a serious and costly problem. Moreover, ceramic fractures pose an aesthetic and functional dilemma both for the patient and the dentist because intraoral repairs for the most part are inadequate. Clinical reports indicate the prevalence of ceramic fractures is between 5 and 10% over a10 year period of use 12. The reasons for structural failure are myriad but always will settle on the inability of the layered ceramic to withstand stresses particularly due to the presence of microcracks and porosities, plus a hydrolytic effect from the wet intraoral environment 13 – 14 - 15

Mechanical failures of metal–ceramic systems are not surprising considering the large differences in modulus between the metal and ceramic materials. When conventional types of dental porcelain are cooled, the leucite crystals contract more than the surrounding glass matrix leading to the development of tangential compressive stresses around the leucite particles as well as to microcracks within and around the crystals 16 – 17 – 18

Wherever a ceramic veneer layer is proportionally offset from the supporting metal substructure or where the forces on the ceramic are disproportionate the processing flaws in the ceramic layer are especially more subject to multifactorial crack propagation 19 - 20 (Fig. 2).

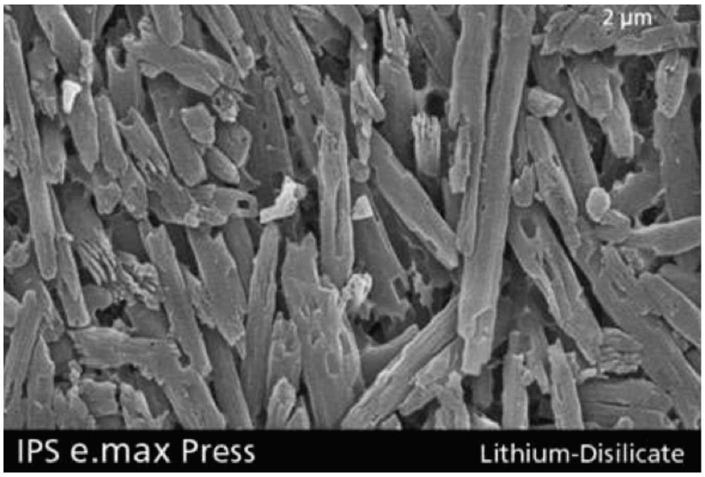


Fig. 1: Lithium Disilicate Structure

Fig. 2: Unsupported Ceramic Fracture

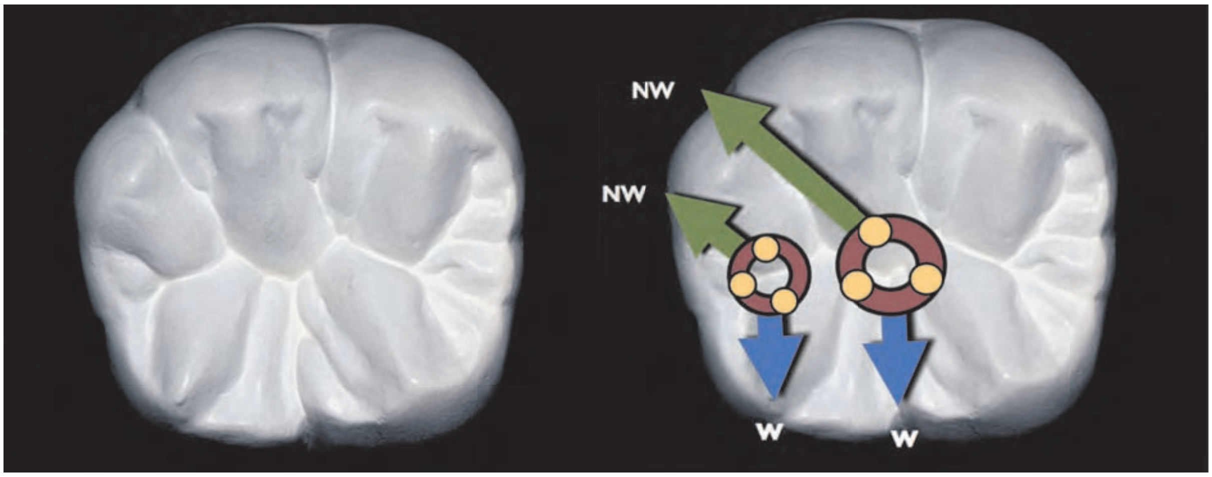


Fig. 3: Cuspal Tripodized Contacts and Egress Pathways

The Requirement for Occlusal Precision

The restoration of a single crown should replicate a biologic balance that is favorable and acceptable to all oral tissues and occlusally it should restore function without inducing any disruptive symptom of mandibular dysfunction 21. Even a single restoration requires a complex organization of cusps, cusp inclines, marginal ridges, occlusal grooves and cusp tip contours. The organization of the occlusion when many or most teeth require working together functionally and in synergy with jaw closure and excursive gliding jaw positions, represents a requirement to have a combination of advanced educational comprehension as well as the ability to perform high levels of clinical and technical skill execution 22 – 23 – 24 – 25 - 26. Most important in creating occlusal harmony is the ability to create dependable indirect occlusal patterns in the restorations in the laboratory that will not warp, shrink or become altered during processing. This is the disadvantage of condensation created porcelains that have high volumetric shrinkage. Even during the final glaze firing if the furnace temperatures are held too high or too long feldspathic composed porcelain surfaces may slump, creating significant inaccuracies of the occlusal contacts 9- 11- 25 .

The Biomechanical Basis of Occlusion

A refined and defined occlusal reconstructive concept will incorporate a number of key elements to develop a biomechanical occlusion. There will need to be a multiplicity of bilateral, uniform ccclusal cuspal and marginal ridge contacts; appropriately developed cusp heights; properly oriented ridges and grooves and a protrusive and latero-protrusive scheme that provides for a disclusion of the posterior teeth during jaw movements.

Practitioners who restore dentitions with a uniform, stable platform of multiplicity of contact points in the posterior dentition and who can then simultaneously organize egress pathways for opposing cusps in excursive jaw movements governed by defining a suitable degree of overbite and overjet will be able to achieve high degrees of biological acceptance that can be expected to significantly resist the deliterious effects of functional and parafunctional events 26 – 27 - 28 (Fig. 3).

In order to achieve these objectives, restorative material selection becomes quite important. Gold restorations have historically been able to perform these requirements best. Other hybrid material systems have not been as successful as gold, including PFM's and layered zirconia. Currently, pressed or CAD created Lithium disilcate restorations seem to be able to replicate what gold restorative materials have done so well, i.e. make a transference of laboratory end result precision to cemented intraoral occlusal precision 33.

Clinically Relevant Properties of IPS e.max

IPS e.max has had well over ten years of development and testing, showing outstanding bench studies as well as successful sample clinical results. Presently however, there are very few extended clinical trial reports as the e.max product has only in the past several years penetrated into widespread usage by the dental profession. Early clinical trial reports that have been published are very promising particularly when compared to precursor lithium dislicate systems 29 – 31 – 32 - 33

The following characteristics of IPS e.max which have been evaluated are:

Monolithic lithium disilicate restorations have been shown to outperform veneered Y-TZP principally due to the weak fatigue resistance of the veneering ceramic 34. When e.max is pressed to zirconia substrate it also performs better than traditional powder-liquid veneering. Monolithic e.max also performs better than powder-liquid veneering of an e.max substrate (Figs. 4 -7).

Fig. 4: Veneering Ceramic on Zirconia Substructure From Ivoclar

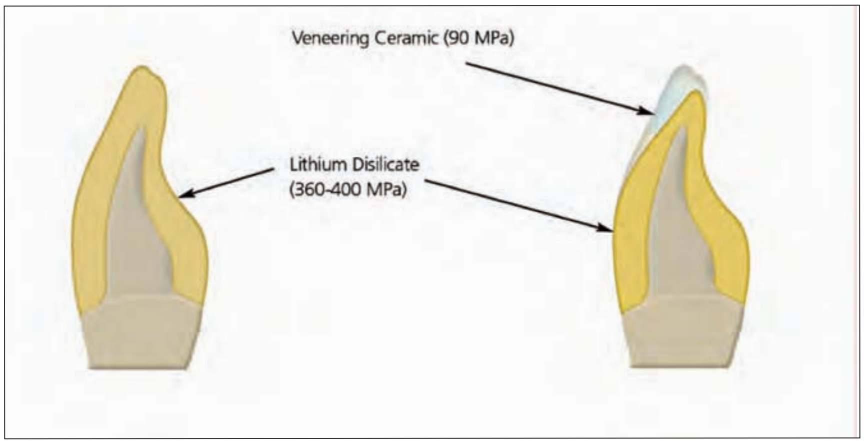


Fig 5: Monolithic and Veneered Lithium Disilicate Fracture Toughness Values From Ivoclar

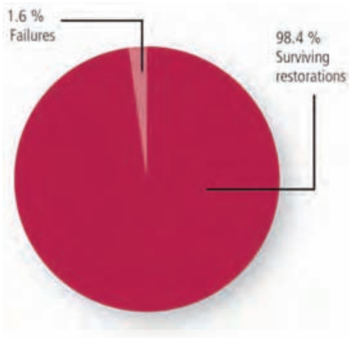


Fig. 6: Monolithic Pressed Lithium Disilicate Survival Values From Ivoclar

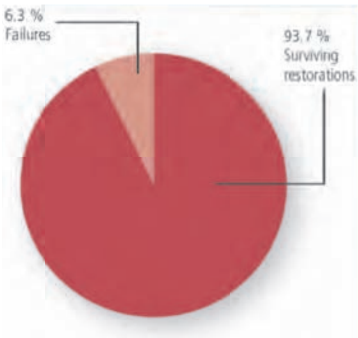


Fig. 7: Veneered Lithium Disilicate Survival Values From Ivoclar

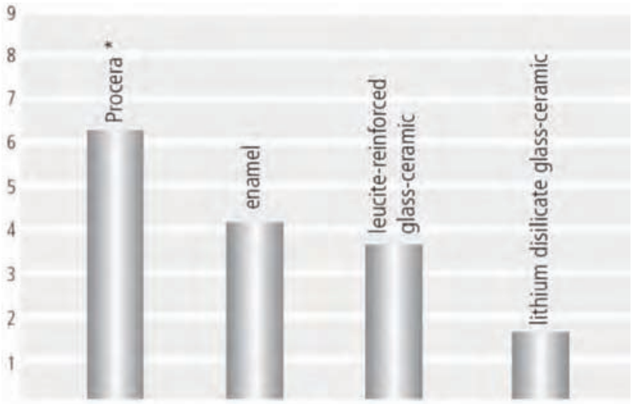


Fig. 8: Lithium Disilicate Wear

Monolithic lithium disilicate restorations have been shown to have excellent in-vivo wear against antagonist ceramic and natural enamel crowns 35 – 36 classifying it as a low abrasion material (Fig. 8)

Monolithic lithium disilicate restorations have been shown to have excellent luting longevity with conventional cementation but particularly by being able to use adhesive bonding. This is particularly important where there is a reduced macrogeometry of prepared tooth structure 37 – 38- 39.

Monolithic lithium disilicate restorations have been shown to have precision marginal fit and when pressed, exhibit precise wax pattern replication 40 – 41 – 42 – 43 – 44 - 45. This feature makes it desirable for developing occlusal accuracy, even for the tripoding of cuspal contacts (Fig. 9).

At 400 megapascals of fracture toughness, pressed lithium disilicate is resistant enough to be used on the occlusal loading surfaces of even second molars and should, for the most part, be able to withstand the effects of nocturnal bruxism without fracturing 46 (Fig. 10).

Conclusion

After half a century of evolution of dental ceramics there exists in the monolithic lithium disilicate version of e.max a restorative material that is esthetic, produces low antagonistic abrasion, exhibits low thermal conductivity, can be adhesively bonded to tooth substrate, has excellent fracture resistance and has high marginal and occlusal accuracy. This material fulfills many of

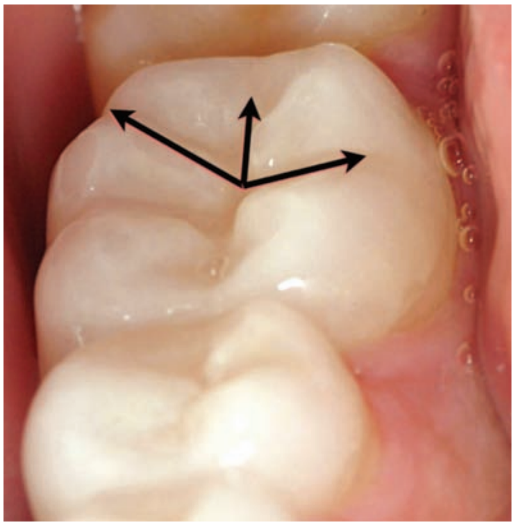


Fig. 9: Precision Excursive Grooves

Fig. 10: ¾ Gold Crown & e.max all Ceramic Complete Crown in a Bruxer

the most desired elements of a contemporary restorative material that can be applied to single units as well as to complete oral rehabilitation cases. Lithium disilicate restorations at this juncture seem to have advantages over time-tested gold as a restorative material 33. However, longer clinical trial terms and reporting are necessary to validate the current early trial results.

About the author

Dr. Nimchuk *is a Prosthodontist, an author and teaching clinician and has given over seven hundred presentations around the world. He has been an honorary sessional lecturer for the Faculty of Dentistry at UBC for over fifteen years. Dr. Nimchuk holds many titles and Fellows, including a position as Associate Editor of the Canadian Journal of Restorative Dentistry and Prosthodontics. Fellow and Honorary Member of CARDP - drn@dentalreconstructions.com*

· *To review references please see page 61 in digital edition.*

· *Continued from page 29 – A New Paradigm For Creating Durable Occlusal Precision With Indirect Bondable Ceramic by Dr. Dennis P.A. Nimchuk, DDS, FRCD(C), FCDS(BC)*

References

1. Erpenstein H, Kerschbaum T, Halrin T. Long-term survival of cast-gold inlays in a specialized dental practice. Clin Oral Investig. 2001;5: 162-166.
2. Hickel R, Manhart J. Longevity of restorations in posterior teeth and reasons for failure. J Adhes Dent. 2001; 3:45-64.
3. Mjör IA, Medina JE. Reasons for placement, replacement, and age of gold restorations in selected practices. Oper Dent. 1993; 18:82-87.
4. Sturdevant CM. The Art and Science of Operative Dentistry. 3rd ed. St. Louis, MO: Mosby; 1995.
5. Donovan T, Simonsen RJ, Guertin G, et al. Retrospective clinical evaluation of 1,314 cast gold restorations in service from 1 to 52 years. J Esthet Restor Dent. 2004; 16:194-204.
6. Patent US3052982 – Fused porcelain to metal teeth, www.google.com/patents/US3052982.
7. Denry IL. Recent advances in ceramics for dentistry. Crit Rev Oral Biol Med. 1996; 7(2):134-143.
8. Tysowsky, G. The Science Behind Lithium Disilicate. 2009-03-01 : Oral Health
9. Randwick.sydneyinstitute.wikispaces.net/.../cms+Firing+Dental+Ceramics.... cms Firing Dental Ceramics.pdf - Randwick College Wiki
10. Rasmussen ST1, Ngaji-Okumu W, Boenke K, O'Brien WJ. Optimum particle size distribution for reduced sintering shrinkage of a dental porcelain Dent Mater. 1997 Jan;13(1):43-50.
11. K.C. Cheung, B.W. Darvel Sintering of dental porcelain: effect of time and temperature on appearances and porosity, Dental Materials 18 2002 163-17312, Motta AB, Pereira, LC, da Cunha, A ; All-ceramic and porcelain-fused-to-metal fixed partial dentures: a comparative study by 2D finite element analyses., J Applied Oral Science vol.15 no5 Aauru Sept./Oct 2007
12. Sorensen JA, Cruz M, Mito WT, Raffeiner O, Meredith HR, Foser HP. A clinical investigation on three-unit fixed partial dentures fabricated with a lithium disilicate glass-ceramic. Pract Periodontics Aesthet Dent. 1999 Jan-Feb; 11(1):95-106.
13. Coornaert, J., Adrians,P.&Deboever, J. (1984) Long-term clinical study of porcelain-fused-to-gold restorations. Journal of Prosthetic Dentistry,51,338
14. Sherill, C.A. & o'brein, W.J. (1974) Transverse strength of aluminous and feldspathic porcelain. Journal of Dental Research,53; 683.
15. Michalske, T.A. & Freiman, S.W. (1982) A molecular interpretation of stress corrosion in silica. Nature,295,511
16. Hasselman, D.P.H. & Fulathy, R.M. (1966) Proposed fracture theory of a dispersion-strengthened glass matrix. Journal of American Ceramic Society,49, 68.
17. Anusavice, K.J. & Zhang, N.Z. (1998) Chemical durability of dicor and fluorocanasite-based glass–ceramics. Journal of Dental Research, 77,1553.
18. Denry, I.L., Ollowey, J.A. & R, S.F. (1998) Effect of ion exchange on the microstructure, strength and thermal expansion behavior of a leucite-reinforced porcelain. Journal of Dental Research,77,583
19. White, S.N. & Li, Z.C., Yu, Z., Kipnis, V. (1997) Relationship between static, chemical, cyclic and mechanical fatigue in a feldspathic porcelain. Dental Materials,13,103.
20. Widerhorn, S.M. (1968) Moisture assisted crack growth in ceramics. International Journal of Fracture Mechanism,4,171
21. Thornton LJ. Anterior Guidance: Group function/Canine Guidance. kA lliterature review. J Prosthet Dent 1990; 64;479-82
22. Ogawa T, Ogimoto T, Koyano K. Pattern of occlusal contacts in lateral positions. Canine protection and group function validity in classifying guidance pattern. J Prosthet Dent 1998;80:67-74.
23. Al-Nimri KS, Bataineh AB, Abo-Farha S. Functional occlusal patterns and their relationship to static occlusion. Angle Orthod 2010; 80:65-71.
24. Ogawa T, Ogimoto T, Koyano K. The relationship between non-working side occlusal contacts and mandibular position. J Oral Rehabil 2001; 28:976-81.
25. Evans DB, Barghi N, Malloy CM, Windeler AS. The influence of condensation method on the porosity and shade of body porcelain; J Prosthetic Dentistry, 63, 380
26. Guichet NF. Biologic laws governing functions of muscles that move the mandible. Part II.Condylar position. J Prosthet Dent. 1977;38(1):35-41.
27. Anderson JR, Myers GE. Nature of contacts in centric occlusion in 32 adults. J Dent Res. 1971;50(1):7-13.
28. Reynolds, J.M., D.D.S Virginia Commonwealth University, School of Dentistry, Richmond, Va., The organization of occlusion for natural teeth; Journal of Prosthetic Dentistry Volume 6,21 , Pages 56–67, July 1971
29. Fasbinder, DJ, Dennison, JB, Heys, MS, Neiva, G; A clinical evaluation of chairside lithiujm Disilicate CAD/CAM crowns: a two year report.JADA,Vol. 141 no. suppl 2 10S-14S
30. Marquardt P, Strub JR. Survival rates of IPS empress 2 all-ceramic crowns and fixed partial dentures: results of a 5-year prospective clinical study. Quintessence Int 2006;37(4):253–259.
31. Stappert CF, Att W, Gerds T, Strub JR. Fracture resistance of different partial-coverage ceramic molar restorations: an in vitro investigation. JADA 2006;137(4):514–522.
32. Pjetursson, B.E., Sailer, I., Zwahlen, M., Hämmerle, Ch. (2007). A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: single crowns. Clin Oral Implants Res. 18 Suppl 3:73-85
33. Nathanson, D. (2008). Clinical performance and fit of a milled ceramic crown system. IADR Abstract #0303, Toronto.
34. Bindl A, Richter B, Mörmann WH. Survival of ceramic computer-aided design/manufacturing crowns bonded to preparations with reduced macroretention geometry. Int J Prosthodont 2005;18 (3):219–224
35. Schaefer O, Watts DC, Sigusch BW, Kuepper H, Guentsch A. Marginal and internal fit of pressed lithium disilicate partial crowns in vitro: a three-dimensional analysis of accuracy and reproducibility.Dent Mater. 2012 Mar; 28(3):320-6. Epub 2012 Jan 21.
36. Schaefer O, Kuepper H, Sigusch BW, Thompson GA, Hefti AF, Guentsch A Three-dimensional fit of lithium disilicate partial crowns in vitro.. J Dent. 2013 Mar; 41(3):271-7. Epub 2012 Dec 7.
37. Lin, WS, Harris, B, Morton, D. Trial insertion procedure for milled lithium
38. Hasselman, D.P.H. & Fulathy, R.M. (1966) Proposed fracture theory of a dispersion-strengthened glass matrix. Journal of American Ceramic Society,49, 68.
39. Anusavice, K.J. & Zhang, N.Z. (1998) Chemical durability of dicor and fluorocanasite-based glass–ceramics. Journal of Dental Research, 77,1553.
40. Schaefer O, Watts DC, Sigusch BW, Kuepper H, Guentsch A. Marginal and internal fit of pressed lithium disilicate partial crowns in vitro: a three dimensional analysis of accuracy and reproducibility.Dent Mater. 2012 Mar; 28(3):320-6. Epub 2012 Jan 21.
41. Schaefer O, Kuepper H, Sigusch BW, Thompson GA, Hefti AF, Guentsch A Three-dimensional fit of lithium disilicate partial crowns in vitro.. J Dent. 2013 Mar; 41(3):271-7. Epub 2012 Dec 7.
42. Lin, WS, Harris, B, Morton, D. Trial insertion procedure for milled lithium disilicate restorations in the crecrystallized state, J Pros Dent, Vol 107, issue 1, 59-62, Jan 2012, 42, Schaefer, O, Watts, Dc., Sigusch,BW, Kuepper, H, Marginal and internal fit of pressed lithim disilicate partial crowns in vitro: a three dimensional analysis of accuracy and reproducibility; Dent Mat 28 (2012) 320-326
43. ReichS, GozdowskiS, TrentzschL, FrankenbergerR, LohbauerU. Marginal fit of heat-pressed vs.CAD/CAM processed all ceramic onlays using a milling unit prototype. OperDent 2008; 33:644–50
44. Anadioti, E., Internal and marginal fit of pressed and cad lithium disilicate crowns made from digital and conventionsl impressions; U of Iowa Theses and Dissertations, 2013, http://ir.uiowa.edu/edt/2435
45. Anadioti, E, Aquilino,SA., Gratton, DG. Holloway, J. it al. 3D and 2D marginal fit of pressed and cad/cam Lithium Disilicate crowns made from digital and conventional impressions; J Pros Dent: 3 July, 2014 doi: 10. 1111/jopr.12180
46. Nishigawa, K, Bando, E, Nakano,M; Quantitative study of bite force during sleep associated bruxism; J Oral Rehabil. 2001 May;28(5):485-91