BIOLOGICAL AND ESTHETIC EVALUATION OF CERAMIC ONLAY WITH DIFFERENT PREPARATION DESIGNS (A RANDOMIZED CONTROLLED CLINICAL TRIAL)

Ahmed Adel Mahmoud Gadallah[1], Omaima Salah El-Din El-Mahallawi[2], Omnia Mohamed El-Shihy[3], Noha Adel Elkhodary[4]

[1]Ph.D. candidate at the Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Egypt. E-mail: Ahmed-adel@dentistry.cu.edu.eg

[2]Professor of Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University, Cairo, Egypt. E-mail: oelmahallawi@dentistry.cu.edu.eg

[3]Professor of Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University, Cairo, Egypt. E-mail: dr.omniamohamed@hotmail.com

[4]Associate Professor of Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University, Cairo, Egypt. Email: noha.elkhodary@dentistry.cu.edu.eg

Corresponding Author:

Ahmed Adel Mahmoud Gadallah

E-mail: Ahmed-adel@dentistry.cu.edu.eg

Abstract:

Purpose: evaluation of biological and esthetical success of ceramic onlay restorations using shoulder finish line preparation versus butt joint with bevel finish line. **Methodology:** 30 participant's were enrolled with total 38 teeth. Ceramic onlay restorations were fabricated for upper premolars. Using two different preparation designs, teeth were randomized into two groups: group (S) for onlay preparation design with shoulder finish line and group (B) for onlay preparation design with butt joint with bevel. Preparations were scanned with intra-oral scanner (Trios 4, 3Shape, Copenhagen, Denmark). Restorations were designed then wax (try-in) restorations were milled using (InLab MC X5, Dentsply Sirona) milling machine. After verification of wax restorations (try-in visit) were sent to the lab to be invested then Lithium disilicate ingots were pressed into the final ceramic onlay restoration for the delivery visit. Onlay restorations were cemented, evaluated for postoperative sensitivity, color match and patient satisfaction using modified USPHS criteria, and followed up for six follow-up sessions with total one-year follow-up period. **Results:** Chi-square statistical test was used to compare the two groups results. For color match group (B) was significantly higher than group (S) regarding Alpha score as $P<0.05$ and for patient satisfaction group (B) was significantly higher than group (S) regarding Alpha score as $P<0.05$. While regarding Post-operative sensitivity there was non-significant difference as both groups scored 100% Alpha ($P>0.05$) after 1 year follow-up. **Conclusions:** ceramic onlay restorations with butt joint bevel exhibited better, color match and patient satisfaction. While regarding post-operative sensitivity both groups revealed satisfactory performance after 1-year follow-up period.

Key words: onlay, e.max, lithium-disilicate, shoulder, bevel.

DOI: 10.48047/ecb/2023.12.Si8.622

1) Introduction:

Teeth with large carious lesions, defective restorations, extensive attrition and erosion have several treatment modalities from the most frequently used treatments are full coverage crowns and onlay restoration. Modern dental treatments are concerned with conserving sound tooth structure and esthetics which advocates the use of onlay restoration as it has several advantages over full coverage restoration as it preserves more tooth structure, less chance for pulpal injury, usually has supragingival margins which is easier for; preparation, annual check-ups, easier cleaning and decreased injury to the surrounding periodontal tissues, decreased chance of secondary caries.

Nowadays minimally invasive dentistry concept has been dramatically increased in recent dental treatments due to improved dental materials and methods of dental restorations fabrication, which makes clinicians routinely in challenge for the selection of the most appropriate treatment [1].

In literature several types of partial coverage indirect posterior restorations have been described such as Inlay; which is intra-coronal restoration without covering any cusp, Onlay which is intra-coronal restoration with covering at least one cusp, Overlay which is intra coronal restoration with coverage for all cusps, Vonlay which is a hybrid restoration of an onlay with an extended buccal veneer surface for use in premolar regions, Occlusal veneer which is a conservative alternative to traditional onlay in which it covers all cusps but without extending intra-coronal [2,3,4] .

Different preparation designs regarding onlay restorations have been described in literature, as preparation differs according to the material of fabrication and position of the tooth. Onlay preparation design plays a critical role in biological, mechanical and esthetic success of restorations. For mechanical and biological success of restoration preparation design should provide the required bulkiness of material without exaggerated weakening of the remaining tooth structure or involvement of the pulp. While for esthetic success preparation design should allow more color blending and hiding of restoration margins [5,6].

Ceramic onlay restorations are getting more widely used by clinicians for mutilated posterior teeth, while on the other hand the literature includes insufficient number of studies exploring the effect of using different preparation designs[7,8]. Consequently, this study examined the effect of using different preparation designs on the biological and esthetical success of ceramic onlay restoration.

2) Materials & Methods:

Thirty participants who met the inclusion criteria were recruited for this study with total 38 Premolars in need of ceramic onlay

restorations. The 38 teeth were submitted randomly to two groups by the aid of a blinded researcher using www.random.org. Two groups were assigned as following ceramic was taken digitally (VITA Easyshade V) and confirmed visually by conventional shade guide (Vita 3D MASTER, VITA Zahnfabrik H. Rauter GmbH & Co.), then putty index was made twice and sectioned. One index was sectioned bucco-lingual and the other mesio-distal and used to standardize the preparation parameters. Teeth were prepared using the same cavity preparation parameters for both groups as following, the isthmus bucco-lingual width was 1.5-2mm. and pulpal floor depth was 2mm. from the central groove while proximal box depth was 1.5mm. and all internal line angles were finished smooth and all axial walls were prepared with occlusal divergence angle 10-12º (Figure 1). For the cusp to be covered was reduced 1.5mm. and according to the assigned group the finish line was prepared a shoulder finish line with 1mm. thickness was made for group (S) or a butt joint with bevel termination with 1 mm width following the buccal contour was done for onlay preparation with shoulder finish line for (Group S) or butt joint with bevel for (Group B). The work flow was done as following after patient agreement and consent approval, shade group (B) {Figure 2 (S)& (B)}. After preparation direct digital impression (intra-oral scan) were taken using (Trios 4, 3Shape, Copenhagen, Denmark), provisional restoration was fabricated and cemented to the prepared tooth. In the lab wax try-in restoration was designed and milled in CAD/CAM machine (inLab MC X5, Dentsply. Sirona) after which wax restoration was sent to the clinic. The researcher tried in the restoration and checked it using 3.5x loops (Ergovision) for complete seating, marginal adaptation and occlusion then wax restoration was sent to the lab in which a well-trained technician invested the wax restoration and IPS e.max press ingot was pressed in press furnace (Programat EP5000 press and ceramic furnace Ivoclar Vivadent AG Schaan, Liechtenstein) following the manufacturer parameters the firing cycle was done and a monolithic ceramic onlay restoration was fabricated.

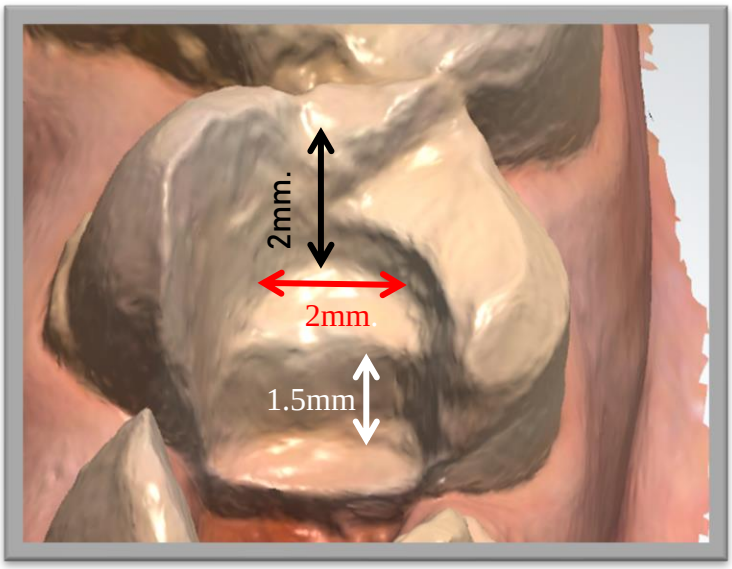

Figure (1) showing width of the ismuth and depth of the pulpal floor and height of the axial wall of the proximal box

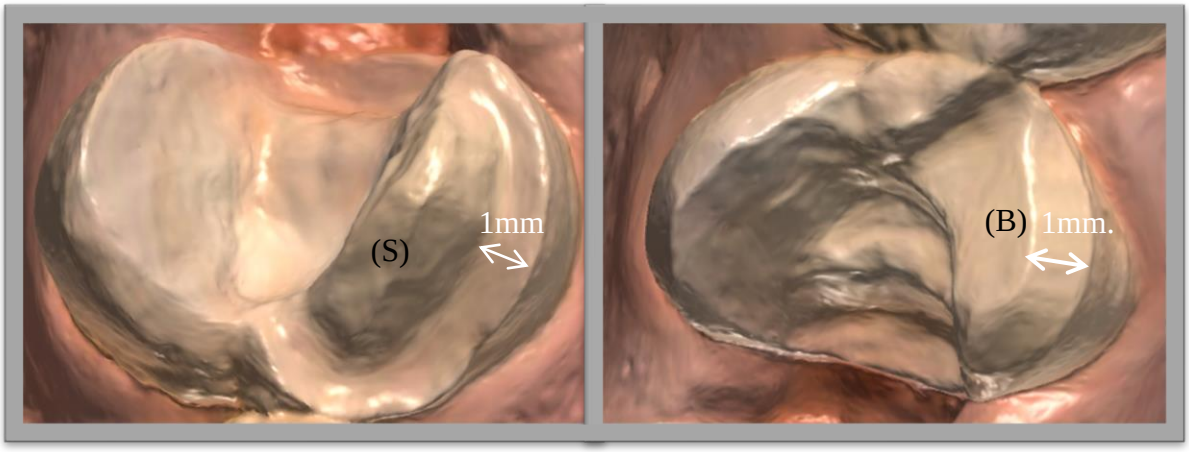

Figure (2) where S is for onlay preparation with shoulder finish line while B is for onlay preparation with butt joint with bevel.

For the delivery visit, the restoration was checked and verified for complete seating proximal contacts, acceptable margins and occlusion. Restoration was cemented using dual cure resin cement (BISCO DUO LINK™ RESIN CEMENT). Modified United States Public Health Service (MUSPHS) criteria was used to evaluate the following outcomes, post-operative sensitivity, color match and patient satisfaction and checked every two months for a period of 1-year follow-up. MUSPHS criteria are described in table (1)

Table (1) presenting outcomes and description of measuring scores used in MUSPHS:

MUSPHS Criteria	Outcome Name	Measuring Score
	Postoperative sensitivity	**Alpha**: Not present, Sensitive but diminishing in intensity **Bravo**: Constant sensitivity, not diminishing in intensity
	Color Match	**Alpha**: matching the adjacent tooth color shade and translucency. **Bravo**: mismatch in color shade and translucency with adjacent teeth but acceptable. **Charlie**: mismatch in color shade and translucency with adjacent teeth but not acceptable.
	Patient's satisfaction	After patient answered questionnaire if patent satisfied **Alpha** score was given and if not satisfied **Bravo** score was given.

3) Results:

Statistical analysis was performed with SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016. Chi-square tests were used for comparisons between group (S) and group (B) for all outcomes, and presented in table (2) and graph (1).

For postoperative sensitivity group (B) was statistically significant higher than group (S) regarding alpha score at T1 as P value recorded was P<0.05 while there was no statistical significant difference between both groups regarding Alpha score at T2 to T6 (after 1 year follow-up) as recorded P value was P>0.05. While for color match group (B) was statically significant higher than group (S) regarding Alpha score at all intervals as recorded P value was P<0.05. For patient`s satisfaction group (B) was statistically significant higher than group (S) regarding Alpha score as recorded P value was P<0.05.

Table (2): Presents summary of results statistical significance in comparison between the two groups after 1-year follow-up:

Outcome	Score	Group Score statistical significance
Post-operative sensitivity	**A**	Group B=S
	B	

Color match	**A**	Group B>S
	B	Group S>B
	C	———
Patient satisfaction	**A**	Group B>S
	B	Group S>B

Where symbols meaning: = Non-significant, ——— = Not recorded, >= statistically significant higher than.

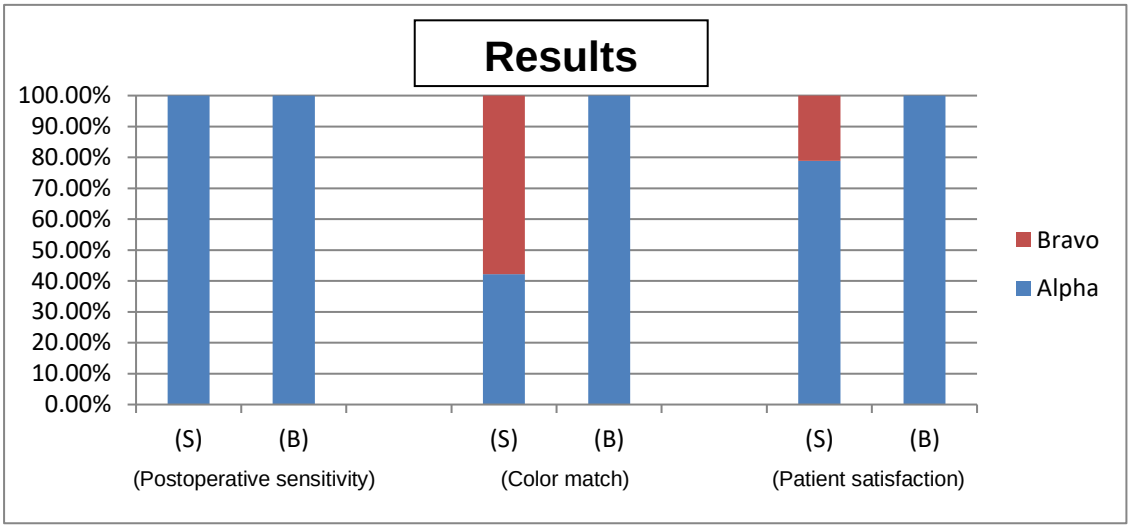

Chart (1) : Describing the results of post-operative sensitivity, color match and patient's satisfaction after 1 year follow-up.

4) Discussion:

Intra-oral scan was done to the prepared tooth and for bite registration as using intra-oral scans combined with milled wax and using pressing technique for fabrication of single ceramic restoration provide restorations with higher marginal adaptation and better internal fit than using physical impression and extraoral scanner for single restoration, also using intra-oral scanner have advantages over conventional impressions as it eliminates dimensional change, easier transportation of impression as it can be send by email to the lab, it takes shorter time than conventional impression, it decreases the long chain of fabrication and more comfortable to patients[9,10, 11,12].

For postoperative sensitivity group (B) was statistically significant than group (S) regarding alpha score at T1 this result may be due to group (S) preparation design is more demanding and have increased number of steps which may lead to increased chance of idiopathic preparatory trauma, such as coolant

onset and its approach to the area of interest, all of this may increase the possibility of postoperative sensitivity. On the other hand group (B) preparation design is more easier which make the clinician more focused on the preparation parameters, also not to mention that group (B) design is easily recorded in impression that may lead to better internal fit which indeed will lead to decreased cement thickness that will decrease postoperative sensitivity. however the pain didn't last long and subsided during the follow-up period. While at T2 to T6 there was no statistical significant difference between both groups this may be due to strictly controlled environment of work as all participants were treated at the outpatient clinic of fixed prosthodontics department, Cairo University while also work was done following meticulously steps as in preparation parameters, temporary restorations and checking & verification of Try-in and delivery restorations all which helped in minimizing the postoperative sensitivity. This result is in agreement with (Santos et al.2017)[13] and (Berkowtz et al.2018)[14] whom found using different onlay preparation designs didn't differ on postoperative sensitivity. They stated this result due to the use of composite resin to cover preparation undercut and deep areas rather than removing sound tooth structure in which this technique was also used in the current study. Also (Bottino et al.2021)[15], (Fasbinder et al.2020)[16],(Santos et al.2016)[17] and (Silva et al.2009) [18] reported no significant difference regarding the postoperative sensitivity whom reasoned this result due to the use of rubber dam meticulous isolation which was used in the current study and additionally explained this result may be due to single appointment procedure as they used chairside restorative technique.

While this result was in disagreement with (Ivanovic et al.2019)[19] and (Archiblad 2018)[20] whom used designs similar to that used in this clinical trial in which they reasoned that postoperative pain was due to different preparation designs which have different conservation parameters of sound tooth structure which can lead to increased postoperative pain.

Also (Samaratzi et al.2021)[21] stated that the amount of tooth tissue removed have significant effect on postoperative sensitivity as when the remaining thickness of tooth structure is 0.5mm. over the pulp 60% of the patients will demonstrate postoperative pain while this percentage decrease to 5% if the remaining tooth structure thickness is more than 1mm.

For color match group (B) revealed statistically significant better results than group (S) due to the use of the bevel which enabled maximum use of ceramic chameleon effect and achieved more color blending this

result was in agreement with (Ruiz et al.2017)[22] who said that the use of bevel allow more color blending and (Tysowsky et al.2018)[23] **,**(Rubena et al.2018)[24] and (Tagetkin et al.2009)[25] whom indicated that using of lithium disilicate ceramics in thin section and higher translucency enable maximum benefit of its chameleon effect. This result was in disagreement with (Elter et al.2022)[26], (Valizadeh et al.2020)[27], (Lee et al.2018)[28] and (Niu et al.2014)[29] as they found that when ceramic thickness decrease the opalescence decrease more than that of the enamel which may adversely affect color match of lithium disilicate restorations.

Patient's satisfaction outcome was measured using MUSPHS criteria this technique was used by (Zuercher et al.2022)[30],(Peumans et al.2013)[31] and (Aristidis et al.2002)[32] Group (B) revealed statistically significant better results than group (S) this result mainly was affected by participants past dental experiences and expectations as, participants whom recorded unsatisfactory response were having dental restoration for the first time, in which it advocates that participant experiences and past dental treatments contributes into their perspective evaluation of the treatment modality[33]. However, this result was in agreement with (Hallmann et al.2019)[34]' (Van Den Breemer et al.2019)[35] and (Oen Kay et al.2014)[36] which found that different preparation designs may led to different patient's satisfaction response and was in disagreement with (Cavalheiro et al.2020)[37]'(Zarone et al.2017)[38]' (Vanlıoğlu et al.2014)[39] (Peumans et al.2000)[40] whom found that different preparation designs have no effect on patient satisfaction. While (Byeon et al. 2018)[41] stated that patient's satisfaction is directly related to number of visits. In addition, it seems that participants were highly interested by the aesthetics outcome of the treatment modality.

5) Conclusions:

Within limitations of this randomized controlled clinical trial, the following can be concluded:

- Ceramic onlay margin design butt joint with bevel can satisfactory replace the shoulder finish line design regarding, color match and patient satisfaction.
- Regarding post-operative sensitivity, both onlay margin designs revealed satisfactory performance after 1-year follow-up period.

6) Acknowledgments:

Staff Members of Fixed Prosthodontics Department

Thanks to the effort of the department staff of professors, Associate professors, lecturers, assistant lecturers and Teaching assistants.

7) Conflict of interest:

Authors declared there was no conflict of interest.

8) Clinical recommendations:

In the event that a posterior tooth is indicated for onlay restoration and there is a necessity to maximize aesthetics, a ceramic onlay with butt joint with bevel margin design is recommended. However, the use of an intraoral scanner is advisable to ensure restorations with high accuracy especially in defining the anatomical ending of the bevel.

9) Funding:

Authors declared that there was no financial assistance provided to this clinical trial.

10) Declaration of Generative AI and AI-assisted technologies in the writing process:

Authors declared they didn't use any of the generative AI and AI-assisted technologies in the writing process.

11) References:

1. Wayakanon, K., Frencken, J. & Tyas, M. Partially Coverage Restoration: An Esthetically Conservative Treatment for a Complex Cavity Restoration. Open J. Stomatol. 07, 234–241 (2019).

2. McLaren, E. A., Figueira, J. & Goldstein, R. E. Vonlays: A Conservative Esthetic Alternative to Full-Coverage Crowns. AEGIS Compend. Contin. Educ. Dent. 36, (2015).

3. Resende, T. H., Reis, K. R., Schlichting, L. H. & Magne, P. Ultrathin CAD-CAM ceramic occlusal veneers and anterior bilaminar veneers for the treatment of moderate dental biocorrosion: A 1.5-year follow-up. Oper. Dent. 43, 337–346 (2018).

4. Shilingburg, H. T. et al. fundamentals of fixed prosthodontics. (2012).

5. Soares, C. J., Martins, L. R. M., Fonseca, R. B., Correr-Sobrinho, L. & Fernandes Neto, A. J. Influence of cavity preparation design on fracture resistance of posterior Leucite-reinforced ceramic restorations. J. Prosthet. Dent. 95, 421–429 (2006).

6. Alassar, R., Samy, A. & Abdel-Rahman, F. Effect of cavity design and material type on fracture resistance and failure pattern of molars restored by computer-aided design/computer-aided manufacturing inlays/onlays. Dent. Res. J. (Isfahan). 18, 14 (2021).

7. Bustamante-Hernández, N. et al. Clinical

behavior of ceramic, hybrid and composite onlays. A systematic review and meta-analysis. Int. J. Environ. Res. Public Health 17, 1–23 (2020).

8. Amesti-garaizabal, A., Verdejo-sol, B. & Fons-font, A. Fracture Resistance of Partial Indirect Restorations Made with CAD / CAM Technology . A Systematic Review and Meta-Analysis. j. clin. med (2019).

9. Park, J. S., Lim, Y. J., Kim, B., Kim, M. J. & Kwon, H. B. Clinical evaluation of time efficiency and fit accuracy of lithium disilicate single crowns between conventional and digital impression. Materials (Basel). 13, 1–18 (2020).

10. Foudda, H., Özcan, M., Marwan, K. & Zeina, M. Marginal and internal fit of pressed lithium disilicate inlays fabricated with milling, 3D printing, and conventional technologies. J. Prosthet. Dent. 119, 783–790 (2019).

11. Koulivand, S., Ghodsi, S., Siadat, H. & Alikhasi, M. A clinical comparison of digital and conventional impression techniques regarding finish line locations and impression time.J. Esthet. Restor. Dent. 32, 236–243 (2020).

12. Cardelli, P., Scotti, R., Baldissara, P. & Monaco, C. Clinical fitting of CAD/CAM zirconia single crowns generated from digital intraoral impressions based on active wavefront sampling. J. Dent. 1–8 (2011).

13. Santos et al. Clinical evaluation of ceramic inlays and onlays fabricated with two systems: 12-year follow-up. Clin. Oral Investig. 20, 1683–1690 (2017).

14. Berkowitz, G. et al. Postoperative hypersensitivity and its relationship to preparation variables in Class I resin-based composite restorations: findings from the practitioners engaged in applied research and learning (PEARL) Network. Part 1. Compend. Contin. Educ. Dent. 34, 1–18 (2018).

15. Bottino, G. de S. et al. Feldspathic and Lithium Disilicate Onlays with a 2-Year Follow-Up: Split-Mouth Randomized Clinical Trial. Braz. Dent. J. (2021).

16. Fasbinder, D. J., Neiva, G. F., Heys, D. & Heys, R. Clinical evaluation of chairside Computer Assisted Design/Computer Assisted Machining nano-ceramic restorations: Five-year status. J. Esthet. Restor. Dent. 32, 193–203 (2020).

17. Santos et al. Clinical evaluation of two types of ceramic inlays and onlays after 6 months. J. Appl. Oral Sci. 12, 213–218 (2016).

18. Silva, R. et al. Clinical performance of indirect esthetic inlays and onlays for posterior teeth after 40 months. Brazilian J. Oral Sci. 8, 154–158 (2009).

19. Ivanović, V. et al. Postoperative sensitivity associated with low shrinkage versus conventional composites. J Appl Oral Sci 141, 447–453 (2019).

20. Archibald, J., Santos, G., Coelho, M. & Santos, M. Retrospective clinical evaluation of

ceramic onlays placed by dental students. J. Prosthet. Dent. 119, 743-748.e1 (2018).

21. Samartzi, T. K., Papalexopoulos, D., Sarafianou, A. & Kourtis, S. Immediate dentin sealing: A literature review. Clin. Cosmet. Investig. Dent. 13, 233–256 (2021).

22. Ruiz, J.-L., Bertolotti, R. & Tagtekin, D. Supra-Gingival Minimally Invasive Dentistry chapter no.6 & 11. (2017). doi:10.1002/9781118976449.

23. Tysowsky, G. W., W, H. & M, S. The science behind lithium disilicate: A metal-free alternative. Dent. Today 28, 112–113 (2018).

24. Rubeena, A.& Malli, N. ONLAY PREPARATION TECHNIQUES - CLINICAL PRACTICE GUIDELINES. Int. J. Curr. Res. 9, 50646–5050 (2018).

25. Tagtekin, D. A., Özyöney, G. & Yanikoglu, F. Two-year Clinical Evaluation of IPS Empress II Ceramic Onlays/Inlays. Oper. Dent. 34, 369–378 (2009).

26. Elter, B., Tak, Ö. & Ottosson, K. Influence of cement shade, ceramic thickness, and airborne-particle abrasion of titanium surface on the final color of monolithic lithium disilicate glass-ceramic hybrid-abutment systems in vitro. Quintessence Int. 53, 678–688 (2022).

27. Valizadeh, S., Mahmoudi Nahavandi, A., Daryadar, M., Özcan, M. & Hashemikamangar, S. S. The effect of ceramic thickness on opalescence. Clin. Exp. Dent. Res. 6, 693–699 (2020).

28. Lee, S. M., Choi, Y. S. & Shu, X. Effect of ceramic material and resin cement systems on the color stability of laminate veneers after accelerated aging. J. Prosthet. Dent. 120, 99–106 (2018).

29. Niu, E., Agustin, M. & Douglas, R. D. Color match of machinable lithium disilicate ceramics: Effects of cement color and thickness. J.Prosthet. Dent. 111, 42–50 (2014).

30. Zuercher, A. N. et al. Randomized controlled pilot study assessing efficacy, efficiency, and patient-reported outcomes measures of chairside and labside single-tooth restorations. J. Esthet. Restor. Dent. (2022) doi:10.1111/jerd.12909.

31. Peumans, M. et al. Four-year clinical evaluation of a self-adhesive luting agent for ceramic inlays. Clin. Oral Investig. 17, 739–750 (2013).

32. Aristidis, G. a & Dimitra, B. Five-year clinical performance of porcelain laminate veneers. Quintessence Int. (Berl). 33, 185–189 (2002).

33. Faraz, Q. et al. Clinical Outcomes and Predictors of Satisfaction in Patients with Improved Lithium Disilicate All-Ceramic Crowns. Med. Princ. Pract. 26, 470–479 (2017).

34. Hallmann, L. et al. Properties of hot-pressed lithium silicate glass-ceramics. Dent. Mater. 35, 713–729 (2019).

35. Van Den Breemer, C., Gresnigt, M., Özcan, M., Kerdijk, W. & Cune, M.

Prospective randomized clinical trial on the survival of lithium disilicate posterior partial crowns bonded using immediate or delayed dentin sealing: Short-term results on tooth sensitivity and patient satisfaction. Oper. Dent. 44, E212–E222 (2019).

36. Oen Kay, T. et al. CAD/CAM versus traditional indirect methods in the fabrication of inlays, onlays, and crowns. Cochrane Database Syst. Rev. (2014) doi:10.1002/14651858.CD011063.

37. Cavalheiro, C. et al. Choosing the criteria for clinical evaluation of composite restorations: An analysis of impact on reliabilty and treatment decision. Pesqui. Bras. Odontopediatria Clin. Integr. 20, 1–8 (2020).

38. Zarone, F., Sorrentino, R., Vaccaro, F., Russo, S. & De Simone, G. Retrospective clinical evaluation of 86 Procera AllCeramTM anterior single crowns on natural and implant-supported abutments. Clin. Implant Dent. Relat. Res. 7, s95–s102 (2017).

39. Vanlıoğlu, B. A. & Kulak-Özkan, Y. Minimally invasive veneers: Current state of the art. Clin. Cosmet. Investig. Dent. 6, 101–107 (2014).

40. Peumans, M., Van Meerbeek, B., Lambrechts, P. & Vanherle, G. Porcelain veneers: a review of the literature. J. Dent. 28, 163–177 (2000).

41. Byeon, S. M. & Song, J. J. Mechanical Properties and Microstructure of the Leucite-Reinforced Glass-Ceramics for Dental CAD/CAM. J. Dent. Hyg. Sci. 18, 42–49 (2018).