https://doi.org/10.48047/AFJBS.6.14.2024.6511-6518

AFJBS African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Comparative evaluation of marginal fit and internal adaptation of endocrowns with various preparation depths fabricated using conventional and optical impression – invitro study

Dr Gayathri Mohan MDS., MBA [1*] and Dr. Anand Selvaraj MDS [2]

[1] Assistant Professor, Department of Prosthodontics, Meenakshi Ammal Dental College and Hospital, Meenakshi Academy of Higher Education and Research (Deemed to be University), Chennai 1; gayathrisona10@gmail.com

[2] Professor, Department of Prosthodontics, Adhiparasakthi Dental College and Hospital, Melmaruvathur, Chengalpattu, Tamilnadu, India 2; dranandselvaraj@gmail.com

* **Correspondence**: gayathrisona10@gmail.com

Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi:10.48047/AFJBS.6.14.2024.6511-6518

Abstract: The aim of the study is to evaluate and compare the marginal fit and internal adaptation of endocrowns with various preparation depths 3 mm, 5 mm, and 7 mm fabricated using conventional and optical impression. 3 mandibular molar root canal models were taken and endodontically treated. Each of them was prepared with different intracoronal depths 3 mm, 5 mm, and 7 mm to receive endocrowns. Conventional putty wash impression was taken for each tooth and die was poured. They were subjected to intra oral scanning and virtual models were produced. The crowns were designed in Dental CAD software and milled using zirconia blanks with a cement space of 70 µm. Fit checker was placed between the milled crowns and their corresponding models. Silicone replica technique was used to visualize the fit checker. The sections were scanned and widths of each wall were measured using a digital microscope. Within the limitations of the study we may conclude that in the presence of a standardized digital intraoral scanner a digital impression that is more accurate than a conventional wash impression can be made up to an intracoronal depth of 7 mm. Intracoronal preparation depth do not seem to affect the marginal fit or internal adaptation of an endocrown whether the impressions are made digitally or using traditional silicone wash impression method.

Keywords: endocrown 1; digital dentistry 2; marginal fit 3

1. Introduction

There are many longitudinal studies stating a high incidence in the need for root canal treatment in the posterior teeth [13-80%]. [1-3] After an endodontic treatment of a severely destroyed tooth, they were traditionally restored by post and core. They adequately stabilised the weak tooth but at the risk of root fracture. An alternative method to effectively restore severely damaged endodontically treated teeth with good resistance to fracture and lack of micro leakage was needed. With the advent of adhesive dentistry endocrowns were first proposed by Pissus in the year 1995.[4]They attained popularity after its detailed description by Bindle and Mormann in 1999.[5]

Endocrowns nicknamed as monoblock restorations are a single unit of both core and crown that anchors into the pulp chamber or even the root canal.[5] Endocrowns follow the principle of minimally invasive preparation with both micro and macro mechanical retention. The macro mechanical retention is obtained from the extension of crown into the axial opposing walls of the pulp.The micromechanical and chemical retention is attained from the adhesive cementation. [6,7] Deeper the pulp cavity and deeper the intracoronal extension, the greater is the surface area for adhesion and transmission of masticatory forces. [8]

Endocrowns are ideal restorative option for endodontically treated short clinical crowns, severely destroyed teeth with two or three walls, increased interocclusal space needing at least 5 mm of occlusal crown thickness, teeth not suitable for post placement [anatomical variations like curved canals, calcified canals etc.]. [9-11] Compared to posts, reinterventions are easier and also shown to allow lesser microbial infiltration owing to its design. [5] Endocrowns are also better options aesthetically as it is made of high strength ceramics. As most are CAD-CAM processed there is lesser chance of error and are superior in strength too. [12]

Marginal fit and internal adaptation are two most important features of an indirect restoration, as a lack of intimate adaptation can lead to erosion of underlying cement due to exposure to oral environment leading to caries and also periodontal problems. [8] For resin cement, a space of about 50-100 microns is considered optimum. A well fitted crown obviously withstands at least twice the load that one with greater cement space. May et al found that when the film thickness increases to 450 microns there is significant loss of fracture resistance due to polymerisation shrinkage. [12,13] Discrepancies in marginal fit can also affect bonding and aesthetics. Internal discrepancies can also lead to crack initiation and propagation. [8] The mechanism behind being an increased interfacial space may create polymerization shrinkage of resin cement and interfacial stresses resulting in decreased strength

Optical impressions are strong alternatives to the conventional wash impressions. Published data revealed the trueness of a single tooth digital impression valued between 6.9 – 27.9 microns and precision value 4.6 - 13.3 microns. [14] Even though a number of dentists have started to use optical scanners to make impressions, the majority of them still use conventional impressions. This is because of lack of clinical research suggesting optical impressions as better alternative to conventional impressions. Especially in cases like restoring an endodontically treated tooth, the impression has to be dimensionally accurate and should record minute details.

There is little evidence to suggest if optical impressions can effectively reproduce deep cavities such as those extending into the pulp chamber or even the radicular space. There is limited data as to whether the internal extension of the endocrown affects its marginal fit and internal adaptation. Also further research is needed to see if this adaptation is better with conventional impressions or with optical impressions.

2. Materials and Methods

The proposal of the study was approved by the institutional ethical board. The sample size calculation and power analysis was done using G*power software [ver 3.1.9; Heinrich-Heine-Universität]. A total sample size of 30 crowns with 5 crowns under each group fulfilled a power of 80%.

3 root canal preparation mandibular tooth models were taken. Each tooth was restored with endocrown of different internal depths 3mm, 5mm and 7 mm respectively. The impressions and the corresponding crowns were categorised as 6 groups - C3, C5, C7, O3, O5, O7 where C refers to conventional impression and O, optical impression and 3, 5 and 7 being the intra coronal depths. Each group contains 5 samples. The teeth were root canal treated using lateral compaction method and the gutta percha removed from the pulp chamber.

Tooth preparation

5 mm occlusal reduction was done to accommodate an adequate thickness of endocrown using course grit wheel shaped diamond. The depth orientation grooves were made and the diamond was directed along the long axis of the tooth parallel to the occlusal plane. [11] This ensures a flat surface determining the position of the cervical sidewalk. This cervical sidewalk should be supragingival [Fig 1]. [9-15] Also enamel wall thickness only less than 2 mm should be removed. A fine particle sized diamond was then used around the entire surface to remove micro irregularities and produce a flat polished surface. [9,16]The axial reduction involved eliminating undercuts in the access cavity. Cylindrical conical green diamond bur within occlusal convergence of 7 degrees was used to make the coronal pulp chamber endodontic access cavity continuous. [9] With the bur oriented along the long axis of the tooth the preparation was carried out without any excessive pressure and without touching the pulpal floor. [15]

A cavity depth of 3 mm for C3 and O3 , 5mm for C5 and O5, 7mm for C7 and O7 done with a cylindrical pivot of 5mm. A ferrule of 1 mm thickness was made using end cutting diamond [Fig 1].

Other attributes of the preparation include a maximum of 7 degree convergence of external walls, supragingival butt joint shoulder finish line of 1-1.2 mm thickness [not more, to preserve enamel for adhesion] and the pulpal floor perpendicular to the axial walls. Bindle advised a total of at least 5mm occlusal diameter and a stump height of at least 3 mm. The preparation followed the same. The occlusal reduction was such that the occlusal porcelain was atleast 5mm thick. [9,16] The models were then mounted on acrylic resin.

Crown fabrication

Conventional single step wash impression was taken using addition silicone [putty and light body consistency [Aquasil; Dentsply] for C3, C5 and C7 [Fig 2]. Type IV Die stone [Pearlstone;Asian chemicals] was used to pour cast.

Digital impression was acquired using intraoral scanner [Primescan; Dentsply Sirona] for O3, O5 and O7 [Fig 3]. The crown was digitally designed in a dental digital software [DentalCAD 3.0 Galway; Exocad] [Fig 4].Crowns were milled from 98*14 ST White zirconia blanks [Zahndent; Zhejiang biotechnology Co ltd] using CADCAM milling machine [MC X5; Dentsply Sirona] and grouped accordingly.

Fit checker

Silicone replica technique proposed by Bachmann in 1992 was used for the study.[17] White PVS material [Fit checker II; GC] was placed between the crowns and model or die and allowed to set under a hydraulic pressure [Fig 5]. Acrylic colours were added to the fit checker for distinguishing easily. The crown was then removed without distorting the fit checker and a layer of addition silicone - light body consistency was injected. The silicone was then removed along with the fit checker. The die surface of the fit checker was then covered with hard wax [modelling wax; Cavex set up hard; Cavex]. This formed a sandwich with fit checker in the middle covered by light body and wax in the top and the bottom. These were then cross-sectioned in the middle to reveal the buccal, occlusal, pulpal and lingual sides of the fit checker.

Measurements

Scanning was done using handheld Celestron digital microscope pro, Model: 44308-DS 5MP and the images were captured. The measurements were done using Dewinter material plus 4.5 calibrated by Erma scale with a least count value of 0.01 microns. The thickness of the fit checker was analysed at the buccal margin, the buccal external wall, the occlusal portion, buccal internal wall, the pulpal floor, lingual internal wall, lingual external wall and the lingual margin [Fig 6].

Statistics

Statistics was done using SPSS Statistics [IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp]. The comparison between conventional impression and digital impression for different preparation depths was done using one-way ANOVA. The comparison between different preparation depths for digital and conventional impression was done using one-way ANOVA and verified with Tukey HSD post hoc test.

3. Results

4. Discussion

In our current study tooth models were used instead of natural teeth for the purpose of standardisation. Eventhough the properties of the models are not similar to natural teeth theyensure a lesser margin of error during preparation and digital scanning. Ferrule wasincorporated in the tooth preparation as it was stated to be a promising rehabilitative technique for severely damaged teeth by Einhorn et al. [17] Also zirconia was used as the material for fabrication of the endocrowns. Several comparative studies have proven that zirconia can be a reliable restorative material for endodontically treated teeth owing to their fracture strength, dimensional change, aesthetics and adaptation to the teeth. [18,19] The silicone replica technique was chosen for marginal fit and internal adaptation assessment as it can be performed intraorally, it is non radiological, economical and highly reliable compared to other methods such as cross sectional methods, triple scan technique, micro computed tomography, optical coherence tomography. [20] The study was done using high quality digital intraoral scanner, digital design software and milling machine to eliminate manual errors.

A detailed descriptive statistics was done to understand the variations of cement space for each wall in all the groups taken into consideration.The greatest space was present pulpal floor area and occlusal area. In C3 the greatest space was 518 microns between pulpal floor and crown, 364 microns between pulpal floor and crown in O3, 674 microns between occlusal surface and crown in C5, 499 microns between pulpal floor and crown in O5,368 microns between buccal margin and crown in C7 and 566 microns between occlusal wall and crown in O7. It can be noted that the external wall gapsare lesser than the marginal gaps in both conventional and digital techniques. On observations of the results it is found that the lingual marginal gaps are lesser than the buccal marginal gaps in both dies and models. In digital impression technique the buccal internal and external wall gaps seem to increase from 3mm preparation design to 7 mm preparation design. But in traditional impression technique the 7mm preparation design has lesser gaps in the buccal areas. The lingual external and internal wall gap values ascend from 3mm to 7mm preparation depths in both conventional and optical techniques. These differences may be due to the overshoot and rounded edges phenomenathat occur during scanning of angled areas especially with a greater depth, such as in axio occlusal line angles or internal angles connecting the pulpal floor in a tooth could contribute to the internal adaptation discrepancy.[22] This discrepancy could affect the crown seating and thus cause marginal gaps. Pinto et al also found a significant 19.6% discrepancy in digital impression for a post space when compared to a conventional impression. [20]

An average cement space of 241 microns was found to be present between the crowns and dieon observing all three groups 3mm, 5mm and 7 mm. It was found to be 222 microns in case of space between crowns and digital models similarly. Among comparison of the cement spaces for each preparation depth 3 mm group seems to have better adaptability eventhough not statistically significant.A greater thickness of fit checkerwas more often found between the pulpal floor and the crown followed by occlusal wall and buccal margin. In our study an average gap thickness of 326 microns in the margins, 120 microns in the external walls, 346 microns in the occlusal area, 322 microns in the pulpal floor and 197 microns in the internal axial walls was found. El Ghoul et al discovered an average cement space of 114 microns in the marginal region, 60 microns in the axial areas, 179 microns in pulpal floor and 110 microns in the internal walls while comparing internal adaptation of CADCAM endocrowns fabricated with different materials. [20]

The inferential statistics involved a series of steps to avoid any inaccuracy in the variables analysed. The homogeneity of variances was checked using Leven's test to ensure that the variables are equally distributed and the ratio statistics was also done. The final inference using one way ANOVA indicated that the models made from digital or optical impressions are as accurate as the conventional impression irrespective of the intracoronal preparation depths.Hence digital impressions can be used for teeth receiving endocrowns upto a pulpal depth of 7mm.

Ideally the marginal and internal gaps must be less than 100 microns, however in our study the resulting cement space was more than the standard parameter. This could be related to the quality of acquisition and processing of data in the digital workflow and the limited ability of milling instruments to reproduce finer details. [21,22] For conventional impression stock tray full arch impressions were not used and rather a single step wash impression for single crown was taken. This may have led to uneven pressure. Also there is a possibility of anisotropic shrinkage of zirconia after the sintering procedure. [23] Also the errors may be attributed to the dimensional changes of the impression material and the die. [24] Several invitro analyses have also compared the digital impression and conventional impression for the fabrication of all ceramic crowns and found that the crowns from intraoral scans have better marginal fit and internal adaptation than from silicone impressions.[25,26] It has been reported that digitally designed crowns were better fitted that those with conventional impressions for fabrication of and zirconia copings and cobalt chromium single crowns too. [27,28] However in 2021 a study on different methods of fabrication of monolithic zirconia endocrowns found no significant difference between digital and conventional impression techniques. [29]

The one way ANOVA followed by post hoc test suggests that there is no statistically significant difference between the different intracoronal preparation depths. Darwish in 2017 in a study to compare the fabrication materials, axial divergence and preparation depths of endocrowns found that there was no significant difference on evaluation of two depths namely 3mm and 5mm. [26] But in 2022 the effect of intracoronal depths 2, 3.5 and 5 mm on the scanning accuracy of industrial scanner and intraoral scanners was assessed and it was concluded that deeper the cavity lesser the accuracy of scanned impression. [23] This statement was also in accordance with Gaintanzoupolou et al and Shin et al who evaluated the marginal fit and internal adaptation of intracoronal preparation depths 2mm, 3mm and 4 mm. [8,30] A study on appraising the marginal fit and internal adaptation of endocrown with no intraradicular extension and with 3 mm extension also found lesser accuracy of fit for the intraradicular extension group. [31] The quality of the scanner and the technique used for fit checking could have played a role in the results of the studies.

Limitations of the study would include a lack of intraoral environment where scanning and impression making could be less precise due to the presence of limited space, saliva and anatomical variations present in the tooth. Also cementation of the crown with a luting agent was not attempted. Distortion of fit checker on separation of crown from tooth is also a notable disadvantage.

5. Conclusions

The marginal fit and internal adaptation of endocrowns made from digital impression is statistically insignificant when compared to endocrowns made from conventional putty wash impression. Within the limitations of the study we may conclude that either a conventional wash impression or in the presence of a standardised digital intraoral scanner, a digital impression can be made up to an intracoronal depth of 7 mm. As for the different intracoronal preparation depths 3mm, 5mm and 7 mm there were no significant difference in marginal fit and internal adaptation for both digital and conventional impressions. Thusintracoronal preparation depth do not seem to affect the marginal fit or internal adaptation of an endocrown whether the impressions are made digitally or using traditional silicone wash impression method. Further investigations is needed on the type of scanners that can maintain the accuracy and if a deeper preparation can be captured digitally.

Author Contributions: Gayathri Mohan "Conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization" Anand Selavaraj "supervision" All authors have read and agreed to the published version of the manuscript."

Funding: Please add: "This research received no external funding"

Institutional Review Board Statement: In this section, you should add the Institutional Review

Data Availability Statement: datasets used in the research will be provided when requested.

Acknowledgments: We acknowledge Mr Jayaraj , METMECH Analaystics, Ekkatuthangal, Chennai for technical support during scanning and measurement of fit checker.

Conflicts of Interest: "The authors declare no conflicts of interest."

References

1. A.R.S. Al-Negrish. Incidence and Distribution of Root Canal Treatment in the Dentition among A Jordanian Sub Population International Dental Journal 2002;52:125-129

2. Ken R. Tilashalski, Gregg H. Gilbert, Michael J. Boykin, Brent J. Shelton. Root Canal Treatment in A Population-Based Adult Sample: Status Of Teeth After Endodontic Treatment Clinical Research August 2004;30:577-581

3. Nataliya Dydyk, Olha Hrynyshyn. Prevalence of Root Filled Teeth in an Adult Population (Lviv, Ukraine) Found On Digital Panoramic Radiographs Wiadomości Lekarskie, April 2020; Lxxiii: 691-695

4. Pissis, P. Fabrication of a Metal-Free Ceramic Restoration Utilizing the Monobloc Technique. Pract. Periodontics Aesthet. Dent. 1995;7:83-94.

5. Bindl A, & Mormann W. Clinical Evaluation of Adhesively Placed Cerec Endo-Crowns after 2 Years: Preliminary Results Journal of Adhesive Dentistry 1999; 1:255-265.

6. Biacchi, G. R., Basting, R. T. Comparison of Fracture Strength of Endocrowns and Glass Fiber Post-Retained Conventional Crowns. Oper. Dent. 2012;37:130-136.

7. Lin, C. L., Chang, Y. H., Hsieh, S. K., Chang, W. J. Estimation Of The Failure Risk Of A Maxillary Premolar With Different Crack Depths With Endodontic Treatment By Computer-Aided Design/Computer-Aided Manufacturing Ceramic Restorations. J. Endod. 2013; 39:375-379.

8. Gaintantzopoulou Md, El-Damanhoury Hm. Effect of Preparation Depth onthe Marginal and Internal Adaptation of Computer-Aided Design/Computer-Assisted Manufacture Endocrowns. Journal of Operative dentistry 2016;4:607-16.

9. Fages M, & Bennasar B. The Endocrown: A Different Type Of All-Ceramic Reconstruction For Molars Journal Of The Canadian Dental Association 2013;79:D140.

10. Marwa Ei Elagra. Endocrown Preparation: Review International Journal of Applied Dental Sciences 2019;5:253-256

11. Gaye Sevimli, Seda Cengiz, M. Selçuk Oruç. Endocrowns: Review J Istanbul Univ Fac Dent 2015;49:57-63.

12. Liliana G. May, J. Robert Kelly, Marco A. Bottino, Thomas Hill. Effects Of Cement Thickness And Bonding On The Failure Loads Of CAD/CAM Ceramic Crowns: Multi-Physics FEA Modeling And Monotonic Testing Dental Materials 2012;28:E99–E109.

13. Felton Da, Kanoy Be, Bayne Sc, Wirthman Gp. Effect Of In Vivo Crown Margin Discrepancies on Periodontal Health. J Prosthet Dent 1991;65:357-64.

14. Ural Park, Ji-Man, Kaleli, Necati, Caglayan and Esma. Evaluation of the Accuracy of Three Different Intraoral Scanners for Endocrown Digital Impression: An In Vitro Study. The Journal of Korean Academy of Prosthodontics. 2020;58:282.

15. Chang Cy, Kuojs, Lin Ys, Chang Yh. Fracture Resistance and Failure Modes of Cerec Endo Crowns and Conventional Post and Core Supported Cerec Crowns. J Dent Sci 2009; 4:110-7.

16. Otto T, Mörmann Wh. Clinical Performance Of Chairside CAD/CAM Feldspathic Ceramic Posterior Shoulder Crowns And Endocrowns Up To 12 Years. Int J Comput Dent 2015;18:147-61.

17. Einhorn, M., Duvall, N., Wajdowicz, M., Brewster, J. And Roberts, H. Preparation Ferrule Design Effect On Endocrown Failure Resistance. Journal of Prosthodontics 2019;28: E237-E242.

18. Atash R, Arab M, Duterme H, Cetik S. Comparison Of Resistance To Fracture Between Three Types Of Permanent Restorations Subjected To Shear Force: An In Vitro Study. J Indian Prosthodont Soc 2017;17:239-49.

19. Dartora Nr, De Conto Ferreira Mb, Moris Icm, Brazão Eh, Spazin Ao, Sousa-Neto Md. Effect Of Intracoronal Depth Of Teeth Restored With Endocrowns On Fracture Resistance: In Vitro And 3-Dimensional Finite Element Analysis. J Endod 2018;44:1179-85.

20. Son K, Lee S, Kang SH. A Comparison Study of Marginal and Internal Fit Assessment Methods for Fixed Dental Prostheses. J Clin Med. 2019;8:785.

21. Leven, R.; Schmidt, A., Binder, R, Kampschulte, M., Vogler, J. Wöstmann, B. et al. Accuracy of Digital Impression Taking with Intraoral Scanners and Fabrication of CAD/CAM Posts and Cores in a Fully Digital Workflow. Materials 2022;15: 4199.

22. Della Bona A. Bonding to ceramics: scientific evidences for clinical dentistry. Artes Médicas. 2009;20:252.

23. Kenyon BJ, Hagge MS, Leknius C. Dimensional accuracy of 7 die materials. J Prosthodont. 2005;14:25-31.

24. Syrek A, Reich G, Ranftl D, Klein C, Cerny B, Brodesser J. Clinical Evaluation Of All- Ceramic Crowns Fabricated From Intraoral Digital Impressions Based On The Principle Of Active Wavefront Sampling. J Dent 2010; 38:553–9.

25. Esilva JS, Erdelt K, Edelhoff D. Marginal and internal fit of four-unit zirconia fixed dental prostheses based on digital and conventional impression techniques. J Clin oral Investig. 2014; 18:515-523.

26. Pradíes G, Zarauz C, Valverde A. Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions based on wavefront sampling technology. J Dent 2015;43:201-208.
27. Al-Atyaa, Zainab & Abdulrahman Manhal. Comparative Evaluation of the Marginal and Internal Fitness of Monolithic CAD/CAM Zirconia Crowns Fabricated from Different Conventional Impression Techniques and Digital Impression Using Silicone Replica Technique (An in vitro study). Biomedical and Pharmacology Journal. 2018;11:477-490.
28. Di Fiore A, De Francesco M, Monaco C, Stocco E, Vigolo P, Stellini E. Comparison Of Accuracy Of Single Crowns Generated From Digital And Conventional Impressions: An In Vivo Controlled Trial. J Osseointegr 2019;11:107-112.
29. An S, Kim S, Choi H, Lee Jh, Moon Hs. Evaluating the Marginal Fit of Zirconia Copings with Digital Impressions withan Intraoral Digital Scanner. J Prosthet Dent. 2014; 112:1171-5.
30. Darwish H. A., Morsi T. S., El Dimeery A. G. Internal fit of lithium disilicate and resin nanoceramic endocrowns with different preparation designs. Future Dental Journal. 2017; 3:67–72.