INTERNATIONAL JOURNAL OF DENTAL MATERIALS

VOLUME 3 NUMBER 1 JANURARY-FEBRUARY 2021

ISSN: 2582 - 2209 (ONLINE)

INTERNATIONAL JOURNAL OF DENTAL MATERIALS

VOL. 3 NO. 1 JANUARY - FEBRUARY 2021

International Journal of Dental Materials

International Journal of Dental Materials

Volume 3 Number 1 January-February 2020

Contents

Focus and Scope

International Journal of Dental Materials (e-ISSN: 2582-2209) welcomes editorial queries, original studies, evidence based research works and practical innovations, reviews, case reports and concise communications. This journal intends knowledge transfer and spread of verified information from valuable researchers to all fellow dental fraternity. Manuscripts showcasing studies on dental biomaterial properties, performance, induced host response, immunology and toxicology will attain the highest priority for publication. Documentation emphasising advancing dental technology, innovations in dental materials design and their clinical viability succeed the hierarchy of publishing preference.

Indexed/Abstracted in;
Crossref, Google Scholar, Open J-Gate, Road, PKP Index, Cite Factor, Scientific Indexing Services (SIS), Directory of Research Journal Indexing (DRJI), and ResearchBib.

Publication Information: International Journal of Dental Materials 2021, volume 3, issue 1 is scheduled for publication. Further details or information is available on this journal's website (https://ijdm.co.in/index.php/dental-materials/).

Advertisement Information:
Advertising orders and enquiries can be sent to;
Assistant Editor,
International Journal of Dental Materials,
Flat No. 602, Narayanadri Heights,
Sanjana Estates, Tadepalli Gudem Road,
Pala Koderu, Bhimavaram – 534202
West Godavari, Andhra Pradesh, India
E-mail: info@ijdm.co.in

Detailed author guidelines can be found from the journal's website (https://ijdm.co.in/index.php/dental-materials/information/authors).

Original Article International Journal of Dental Materials 2021; 3(1) ISSN:2582-2209

Comparative evaluation of micro-tensile bond strength between zirconia core and all-ceramic layering with different surface treatments: an *in vitro* study

Surya Kiran Yadavilli[1], Anitha Viswanathan Kuttae[2], Alekhya NV Ghandikota[3,*]

[1]Senior Lecturer, Department of Prosthodontics, Rungta Dental College, Bhilai, India.
[2]Reader, Department of Prosthodontics, SRM Dental College, Ramapuram, Chennai.
[3]Senior Resident, Department of Orthodontics, SCB Dental College and Hospital, Cuttack.

INFORMATION

Article History

Received 7th *November 2020*

Received revised *18th January 2021*

Accepted *21st January 2021*

Available online *22nd February 2021*

KEYWORDS

Zirconia

All ceramics

CAD-CAM

Sandblasting

Acid etching

Zirliner

Glass beads

SEM.

ABSTRACT

Background: The quest for newer and stronger materials for replacing teeth has resulted in Zirconium oxide's introduction, which possesses excellent mechanical strength and toughness. However, uncertainty exists in the relationship between its bond strength and surface treatment method adopted and the mode of failure at the interface.

Aim: The study aimed to evaluate the comparison of micro-tensile bond strength between the zirconia core and all-ceramic layering with different surface treatments and analyse their failure mode by Scanning Electron Microscope (SEM).

Materials and methods: Zirconia cores (Ceramill ZI 71 XS) were fabricated by CAD-CAM into discs with 5mm diameter and 3.5mm height. Then the cores were divided into four groups. Among which, Group-I was the control group, and the remaining were surface treated. Group-II specimens were treated with sandblasting, followed by acid etching; Group-III and Group-IV were treated with zirliner and glass beads, respectively. After that, the veneering material (IPS Empress, E.max Ceram Dentin) of 2×2 mm was adhered to the zirconia core and then kept in the ceramic furnace. The specimens were mounted on a Universal Testing Machine, and tensile stress was applied. The obtained data were subjected to One-way ANOVA and Tukey-HSD tests for statistical analysis.

Results: The samples treated with sandblasting followed by acid etching showed more micro-tensile bond strength at core and veneer interface. Furthermore, the SEM study revealed a cohesive failure in Group-II, whereas, in Group-I and -III, there was an adhesive failure. Group-IV specimens exhibited a mixed failure. One -way ANOVA showed significant differences ($p=0.001$) within the groups. In posthoc analysis, Group-III showed significant differences with Groups -I, II, and IV.

Conclusion: Increased surface roughness of zirconia obtained by sandblasting with aluminium oxide particles, when coupled along with chemical etching with hydrofluoric acid, enhanced the micro-tensile bond strength between the Y-TZP zirconia core and veneering ceramic.

1. Introduction

Teeth are considered the most important component of the stomatognathic system and their loss leads to an imbalance in harmony in the masticatory apparatus [1]. Porcelain holds a special place in dentistry as it is considered most

Correspondence: *Corresponding author Email Address: *alaykkyaghandikota@gmail.com*

How to cite this article: Surya YK, Anitha KV, Alekhya G. Comparative evaluation of micro-tensile bond strength between zirconia core and all-ceramic layering with different surface treatments: an *in vitro* study. Int J Dent Mater 2021;3(1): 01-07. *DOI: http://dx.doi.org/10.37983/IJDM.2021.3101*

aesthetic restorative material with good translucency. Further, it is highly biocompatible among the materials used in dentistry [2]. Combining better manufacturing techniques such as computer-aided design/computer-aided manufacturing (CAD-CAM) with stronger materials has increased the possibility of using all-ceramic restorations for dental applications. The advancement in technology has improved the fracture toughness, wear resistance, machinability, hardness and flexural strength of ceramics [3-7]. Zirconium oxide was introduced as a core material for all-ceramic restorations due to its good chemical properties, high mechanical strength, toughness, and Young's modulus similar to that of stainless steel [8].

All-ceramic material failures reported, were either as delamination of veneering ceramic from the core ceramic or sometimes in the form of cracks on the core material itself. There are various reasons for these types of failures, such as, crack propagation of core material which reduces bonding effect, insufficient thermal expansion due to a sudden change in temperature during the conversion of the liquefied stage to the solidification stage and various transformations of crystalline stage [9].

Several studies suggested that a tensile bond strength test may be more appropriate for evaluating adhesive interfaces' bond strength because of more uniform interfacial stresses [2,3]. The micro-tensile bond strength test was developed to eliminate the non-uniform stress distribution at the adhesive interface, and it has been used to measure the bond strength [8]. Hence, this study was designed to evaluate the effect of various surface treatments on the micro tensile bond strength of layered ceramic on the zirconia core and compare them. Further, this study has also analysed the mode of failure using a Scanning Electron Microscope (SEM).

2. Materials and methods

Pre-sintered Y-TZP zirconium oxide blanks (Ceramill ZI 71 XS, Dental arch form, h=12mm Amann Dental Gmbh and Girrbach Dental Gmbh, AmannGirrbach, Austria) were used for core fabrication using CAD-CAM technology.

2.1 Fabrication of Aluminium metal dies for core

A standard metal disc having a 14 mm external diameter, 10mm of internal diameter and a thickness of 4mm with 3.5mm height was fabricated from aluminium blocks by lathe milling. The inner surface was smoothened using files and abrasive papers (Ecomet, Buehler LTD, Evanston, Ill, USA).

2.2 Fabrication of Aluminium Metal Die for Layering Ceramic

An aluminium disc measuring 6mm external diameter, 2mm internal diameter and thickness of 2mm with a height of 2mm was fabricated from aluminium blocks by lathe milling. The aluminium block was shaped and trimmed using the lathe cutter. The die measurements were verified using electronic Vernier Calipers (Mitutoyo Corp, Tokyo, Japan).

2.3 Fabrication of Core

The standard metal disc was used for the preparation of 40 core samples. Pre-sintered Y-TZP Zirconium oxide blanks (Ceramill ZI 71 XS, Dental arch form, h=12mm Amann Dental Gmbh and Girrbach Dental Gmbh, AmannGirrbach, Austria) were used for core fabrication using CAD-CAM technology. A Ceramill map 300 scanning machine was used to scan the metal die, and later, the design was transferred to the Ceramill motion, and zirconia samples were prepared (Figure 1).

2.4 Surface treatment for Core

Forty samples were fabricated by the Ceramill motion milling machine and were steam washed adequately. The samples were then divided into four different groups (Table 1). Group-I with no surface treatment was used as the control group against which the other three surface treatments were compared. For Group-II samples, first sandblasting with 120µm of aluminium oxide (Al_2O_3) (Cobra, Renfert, Strahimittei, Germany) was done for 1 minute (Figure 2). The samples were then etched by 5% hydrofluoric acid (IPS ceramic Refill, Ivoclar Vivadent, Germany) for 1 minute (Figure 3). The surfaces of the Group-III samples were treated with Zirliner (IPS-E.max, Ivoclar Vivadent, Germany). It was mixed into a creamy consistency and then was applied to the zirconia core until an even greenish colour effect was achieved. After the application, the zirliner was properly dried and fired in the ceramic furnace (Programmat-P 100, Ivoclar Vivadent AG, Schaan, Liechtenstein) according to the manufacturer's instructions. Group IV samples were surface treated with glass beads of 50µm (Rolloblast, Renfert, Strahlmittel, Germany) for 1 minute (Figure 4).

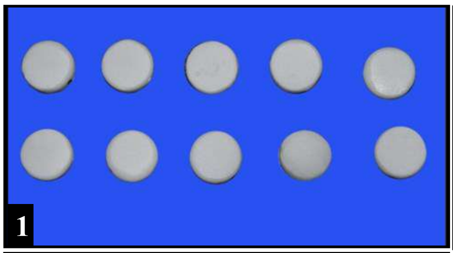
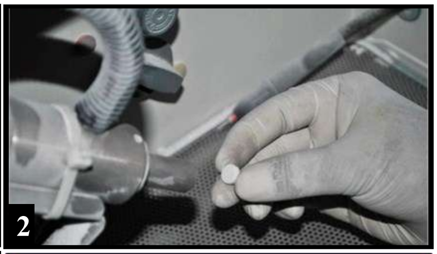
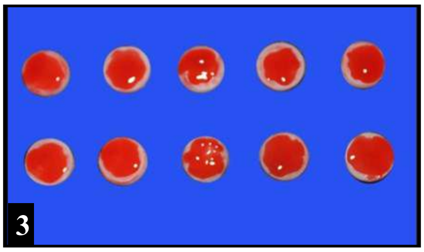
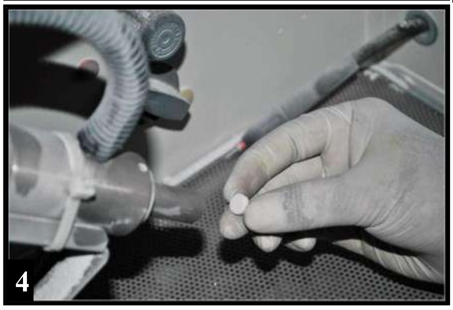





Figure 1. Prepared Zirconia core Discs.
Figure 2. Sandblasting the core ceramic surface with alumina.
Figure 3. Etching the ceramic Core with hydrofluoric acid.
Figure 4. Sandblasting the core surface with glass beads.
Figure 5. Veneering ceramic on the zirconia core before heating.
Figure 6. Prepared zirconia core and veneer after heating.

Figure 7. Evaluation of Micro-tensile bond strength at core ceramic and layered ceramic.

Table 1. Surface treatments used in various groups

Groups	N	Surface treatment
I	10	No surface treatment
II	10	Sand blasting+Hydrofluoric acid
III	10	Zirconia liner
IV	10	Glass beads

Table 2. Mean and standard deviation of Micro-tensile bond strength (MPa) of Ceramic specimens.

Groups	N	Mean ± SD#	Significance
Group –I	10	81.43±26.87	0.001*
Group –II	10	99.89±21.97	
Group –III	10	54.28±18.85	
Group –IV	10	76.68±30.49	

Standard Deviation; * Significant

Table 3. Comparison of micro-tensile bond strength of ceramic specimens (Post-hoc analysis)

Groups		Mean Difference	Significance
Group -I	Group -II	18.46	0.098
	Group -III	27.15	0.005*
	Group -IV	4.76	0.931
Group -II	Group -III	45.61	0.001*
	Group -IV	23.21	0.022*
Group -III	Group -IV	22.40	0.029*

* Significant

2.5 Application of Layer Ceramic to the Core Specimen

Aluminium dies fabricated for specified dimension was used for layering procedure. The recommended ratio of layering powder and liquid were taken and mixed on the ceramic mixing slab. The layering with the dentin body of D4 shade was kept in the ceramic furnace (Programmat-P 100, Ivoclar Vivadent AG, Schaan, Liechtenstein) (Figures 5 and 6).

2.6 Evaluation of Micro-tensile bond strength (MTBS)

The samples were attached with nickel-chromium stands of 3cm length to the layering ceramics to secure it on the testing machine. The specimen was mounted for testing in Universal Testing Machine (Instron) and tensile load was applied at a crosshead speed of 1 mm/ min (Figure 7).

2.7 Scanning Electron Microscope (SEM) analysis

The failure modes at the fracture site were analyzed using Scanning Electron Microscope (Quanta200 F). The specimens obtained following the MTBS testing were subjected to SEM under a specific magnification of 250X.

The data were subjected to One-way ANOVA and Tukey-HSD tests for statistical analysis using SPSS for Windows, Version 21.0., SPSS Inc.

3. Results

The Normality test results, Kolmogorov-Smirnov and Shapiro-Wilk tests showed that the sample did not follow the normal distribution. Therefore, to analyse the data, non-parametric tests were applied. To compare micro-tensile bond strength (MPa) between all the four groups, Kruskal Wallis was applied, and for pairwise comparison, Mann-Whitney U tests with Bonferroni corrections were used.

The mean micro-tensile bond strength of the groups is given in Table 2. The ceramic specimens treated with both sandblasting and hydrofluoric acid (Group-III) exhibited more micro-tensile bond strength among the groups (Table 2). The ceramic specimens treated with Zirconia liner demonstrated the least micro-tensile bond strength. One-way ANOVA showed significant differences ($p=0.001$) within the groups.

In Post-hoc analysis, Group-III showed significant differences with Groups I ($p=0.005$), -II ($p=0.001$) and -IV ($p=0.029$). The group-II specimens also exhibited significant differences ($p=0.022$) with group IV (Table 3).

SEM analysis showed adhesive and cohesive debonding in the layers of ceramic (Figures 8 a-d). The ceramic specimens in group-I and -III showed adhesive failure and the group -II specimens showed cohesive failure (Table 4). The specimens in group-IV exhibited both adhesive and cohesive failures.

4. Discussion

Material selection, performances, and clinical recommendations on layered all-ceramics are based on standard mechanical testing methodologies [9]. Information on the best combination of zirconia core and veneering ceramic could help the clinician predict possible fracture or debonding at the core-veneering ceramic interface [10]. In this study, Yttria-stabilized Tetragonal Zirconia Polycrystals (Y-TZP) were used for the core fabrication. A low fusing nano-fluorapatite glass-ceramic was used for the veneering of the Zirconia core. The presence of nano-fluorapatite crystal structure (100-200 nm) with a length of 1-2 µm enhanced the material's optical property. The material could also be used as a single layering material for veneering [11,12]. With the application of layered ceramic on the Zirconia core, there have been many changes in the stress distribution pattern that makes its performance to be hardly predictable in a clinical scenario [13]. Thus, the present study aimed to determine the bond strength between the Zirconia Oxide core and the layering ceramic.

For improving bond strength, sandblasting is a popular means by increasing surface roughness and providing undercuts [14,15]. However, sandblasting also initiates phase transition, affecting the mechanical strength and, most probably, the material's bonding capacity [16]. On this score, the effect of sandblasting on the mechanical strength of Y-TZP & the bond quality to veneering ceramics is thus, an intensely studied subject and was adopted as one of the surface treatments in the present study. Having employed a low-fusing nano-fluorapatite glass-ceramic as a veneer material for CAD/CAM Y-TZP zirconia core, an etchant gel was used after sandblasting to study the effect on bond strength. The application of liner material to mask the white colour of Zirconia and to improve the

Table 4. Percentage of mode of failure in different groups .

Groups	Adhesive Failures (Between core and veneer)	Cohesive Failure (Within veneer)	Mixed Failure (Combination of both)
I	100%	0%	0%
II	0%	100%	0%
III	100%	0%	0%
IV	50%	40%	10%

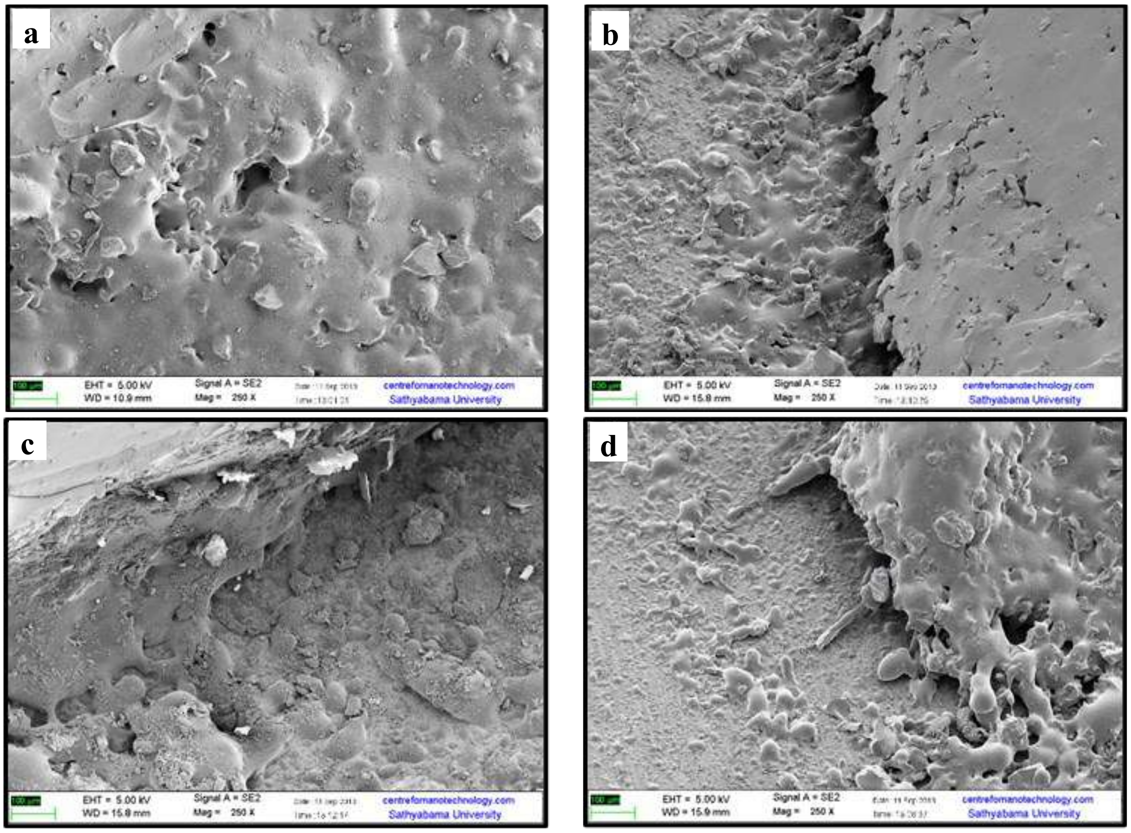


Figure 8. SEM analysis of bonding failure. Where a. Adhesive failure observed in group-I specimens; b. Cohesive failure observed in group-II specimens; c. Adhesive failure observed in group-III specimens; and d. Group-IV specimens exhibited both adhesive and cohesive failures.

bond strength between the core and the veneer layers has been studied before [17]. With IPS e.max Ceram as layering material, the corresponding liner was used to evaluate the effect of bond strength. The non-abrasive glass beads for smoothing and condensing of the ceramic surface have been used in the study with 50μm, to decrease the crack formation during function [18]. With the several perplexities among the different surface treatments of bilayered ceramics, a comparison was made to emanate the results.

This study showed that Group II had the highest mean bond strength compared to other groups (Table 2). The p-value was significant (0.010) as was found in the Kruskal-Wallis Test. Group-III demonstrated the least bond strength among all the four groups. When each group was compared with the control group (Group-I), specimens with sandblasting along with acid etching (Group-II) elicited the highest micro-tensile bond strength values (MTBS). Minimal variation of the standard deviation of all four groups with enhanced MTBS values could be attributed to the use of high-performance zirconia oxide in tetragonal metastable form as core and compatible low fusing fluorapatite glass-ceramic as veneer material [17]. In the control group, debonding occurred at the interface between the core and the veneer material as revealed by the SEM images. Hence, an adhesive mode of failure materialized in Group-I. This may be partly due to large differences in the flexural strengths between the two ceramics and more significantly, any mismatch in the elastic moduli [19].

The MTBS values when compared with Group II showed little less bond strength, confirming the results of the previous studies in which the various surface treatments showed an improvement in MTBS [20]. Group-II specimens where both mechanical and chemical mode of surface treatments were employed showed the highest MTBS, and they were in compliance with prior studies [21,22]. After the mechanical interlocking with airborne abrasives, hydrofluoric acid etchant application was done on the ceramic layer. Use of acid alone on zirconia is difficult due to its chemical inertness [23]. However, acid etching is a commonly used method for silica-based glass-ceramic surfaces and hence was coupled along with sandblasting [24].

The results of Group-III were in contrast to the study done by Fleming *et al.* (2004) [25] where an increase in strength was found at the smooth interfacial surface. But the outcome supported the research done by Aboushelib *et al.* (2010) [23]. In Group III, no mechanical porosities were created, and only Zirliner was applied, which could be attributed for the least MTBS.

The use of glass beads in Group-IV showed a nominal difference in MTBS compared to the control group. A mixed adhesive and cohesive debonding was detected in the layers of ceramic (Table 4).

Non-abrasive particles, unlike Al_2O_3, usually employed for surface treatment and divesting of all-ceramic materials, increased the bond strength but not to a very great extent. In general, the thicker the zirconia and veneering ceramics, the higher the residual stresses. The specimen ratio in this study was high, with 5mm thick zirconia disc and 2mm veneering porcelain than represented in typical dental restorations [20].

5. Conclusion

The increased surface roughness of zirconia obtained by sandblasting with aluminium oxide particles, coupled with chemical etching with hydrofluoric acid, enhanced the micro-tensile bond strength between the Y-TZP zirconia core and veneering ceramic.

Conflicts of interest: Authors declared no conflicts of interest.

Financial support: None

Acknowledgement

We extend our thanks to Dr. Faiz, MDS (Head of Ankhor Laboratory), Dr. Bhuvana (Department of Testing, CIPET), Mr. Arul (Research Scholar, Satyabhama university, Mr. Giri (Research Scholar, Anna University) and Mr. Bhoopathi (Bio-statistician) for their support.

References

1. Heartwell CM, O'Rahn A. Textbook of complete dentures. Hamilton, Ont.: BC Decker Incorporated; 2002.
2. Denry I, Holloway JA. Ceramics for dental applications: a review. Materials, 2010;3(1):351-68. https://doi.org/10.3390/ma3010351
3. Griggs JA. Recent advances in materials for all-ceramic restorations. Dent Clin North Am. 2007;51 (3):713-27.https://doi.org/10.1016/j.cden.2007.04.006
4. Dong JK, Luthy H, Wohlwend A, Schärer P. Heat-pressed ceramics: technology and strength. Int J Prosthodont. 1992;5(1): 9-16.
5. Payal. Exploring Best Fit-Dental Materials for CAD/CAM. Int J Dent Mater. 2020;2(2):45-51. https://doi.org/10.37983/IJDM.2020.2203
6. Babu PJ, Alla RK, Alluri VR, Datla SR, Konakanchi A. Dental ceramics: Part I–An overview of composition, structure and properties. Am J Mater Eng Technol. 2015;3(1):13-8.
7. Datla SR, Alla RK, Alluri VR, Babu JP, Konakanchi A. Dental ceramics: Part II-Recent advances in dental ceramics. Am J Mater Eng Technol. 2015;3(2):19-26.
8. Benetti P, Della Bona A, Kelly JR. Evaluation of thermal compatibility between core and veneer dental ceramics using shear bond strength test and contact angle measurement. Dent Mater. 2010;26(8): 743-50. https://doi.org/10.1016/j.dental.2010.03.019
9. Al-Dohan HM, Yaman P, Dennison JB, Razzoog ME, Lang BR. Shear strength of core-veneer interface in bi-layered ceramics. J Prosthet Dent. 2004;91(4):349-55. https://doi.org/10.1016/j.prosdent.2004.02.009
10. Messer PF, Piddock V, Lloyd CH. The strength of dental ceramics. J Dent. 1991;19(1):51-5. https://doi.org/10.1016/0300-5712(91)90040-6
11. Anusavice KJ, Shen C, Rawls HR, editors. Phillips' Science of Dental Materials. Elsevier Health Sciences; 2012 Sep 27.
12. Alla RK. Dental Materials Science, India: Jaypee Medical Publishers (P) Ltd., 2013. https://doi.org/10.5005/jp/books/12018
13. Kwon TK, Pak HS, Yang JH, Han JS, Lee JB, Kim SH, Yeo IS. Comparative fracture strength analysis of Lava and Digident CAD/CAM zirconia ceramic crowns. J Adv Prosthodont. 2013;5(2):92-7. https://doi.org/10.4047/jap.2013.5.2.92

14. De Jager N, Pallav P, Feilzer AJ. The influence of design parameters on the FEA-determined stress distribution in CAD–CAM produced all-ceramic dental crowns. Dent Mater. 2005;21(3):242-51. https://doi.org/10.1016/j.dental.2004.03.013
15. Luthardt RG, Sandkuhl O, Reitz B. Zirconia-TZP and alumina-advanced technologies for the manufacturing of single crowns. Eur J Prosthodont Restor Dent. 1999;7(4):113-9.
16. Kosmač T, Oblak C, Jevnikar P, Funduk N, Marion L. The effect of surface grinding and sandblasting on flexural strength and reliability of Y-TZP zirconia ceramic. Dent Mater. 1999;15(6):426-33. https://doi.org/10.1016/S0109-5641(99)00070-6
17. Aboushelib MN, de Jager N, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of different components of core veneered all-ceramic restorations. Dent Mater. 2005;21(10):984-91. https://doi.org/10.1016/j.dental.2005.03.013
18. Obradović-Đuričić K, Medić V, Dodić S, Gavrilov D, Antonijević Đ, Zrilić M. Dilemmas in zirconia bonding: A review. Srpski arhiv za celokupno lekarstvo. 2013;141(5-6):395-401. https://doi.org/10.2298/SARH1306395O
19. Dündar M, Özcan M, Gökçe B, Çömlekoğlu E, Leite F, Valandro LF. Comparison of two bond strength testing methodologies for bilayered all-ceramics. Dent Mater. 2007; 23(5):630-6. https://doi.org/10.1016/j.dental.2006.05.004
20. Harding AB, Norling BK, Teixeira EC. The effect of surface treatment of the interfacial surface on fatigue-related microtensile bond strength of milled zirconia to veneering porcelain. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2012;21(5):346-52. https://doi.org/10.1111/j.1532-849X.2012.00843.x
21. Fischer J, Stawarczyk B, Sailer I, Hämmerle CH. Shear bond strength between veneering ceramics and ceria-stabilized zirconia/alumina. J Prosthet Dent. 2010;103(5):267-74. https://doi.org/10.1016/S0022-3913(10)60056-X
22. Teng J, Wang H, Liao Y, Liang X. Evaluation of a conditioning method to improve core-veneer bond strength of zirconia restorations. J Prosthet Dent. 2012;107(6):380-7. https://doi.org/10.1016/S0022-3913(12)60095-X
23. Aboushelib MN, Feilzer AJ, Kleverlaan CJ. Bonding to zirconia using a new surface treatment. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2010;19(5):340-6. https://doi.org/10.1111/j.1532-849X.2010.00575.x
24. Blatz MB, Sadan A, Kern M. Bonding to silica-based ceramics: clinical and laboratory guidelines. Quintessence Dent Technol. 2002;25:54-62.
25. Fleming GJ, El-Lakwah SF, Harris JJ, Marquis PM. The influence of interfacial surface roughness on bi-layered ceramic specimen performance. Dent Mater. 2004;20(2):142-9. https://doi.org/10.1016/S0109-5641(03)00085-X

Original Article *International Journal of Dental Materials 2021; 3(1)* **ISSN:2582-2209**

Prevalence of middle mesial canals and Isthmi in mandibular molars in a subpopulation of Andhra Pradesh: an *in vivo* investigation using CBCT

Girija S Sajjan[1,*], Rajashekar Ch[2], Madhu Varma K[1], Kalyan Satish R[1], Rishitha T[3], Srikanth G[4]

[1]Professor, [4]Postgraduate Student, Department of Conservative Dentistry and Endodontics, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[2]Senior Lecturer, Department of Conservative Dentistry and Endodontics, Meghana Institute of Dental Sciences, Nizamabad, Telangana, India.

[3]Senior Lecturer, Department of Conservative Dentistry and Endodontics, St Joseph Dental College and Hospital, Eluru, Andhra Pradesh, India.

INFORMATION

Article History

Received *14th December 2020*

Accepted *21st January 2021*

Available online
22nd February 2021

KEYWORDS

CBCT Dental

Isthmi

Mandibular molars

Middle mesial canal

Operating microscope

ABSTRACT

Background: Pulp and root canal space is enigmatic and highly complex. Encountering rare has become a norm with the advancements in the technology of materials and types of equipment. The success of the root canal treatment depends on the effective removal of bacteria from the whole pulp space. A high percentage of the missed canal is reported for the failure of Endodontic therapy. Mandibular molars have complex root canal anatomy. Two roots with two canals in mesial root and one to two canals in distal root is a common occurrence. Nevertheless, the incidence of variation is relatively high, including separate distolingual, mesiobuccal, C-Shaped canals, isthmus, and additional canal in the mesial root. A wide range of the middle mesial canal occurrence, i.e., 3.1 to 46.1%, is reported in the world and 28.3% in North India.

Aim: To identify the prevalence of the true middle mesial canal (MM) and configuration of Isthmi in the mesial root of the mandibular molar in the AP subpopulation of South India.

Materials and methods: CBCT of 89 patients were randomly selected from the institutional database. Data entry was performed in Excel, and data analysis was done with the Statistical Package for Social Sciences (SPSS).

Results: Four images (4.5%) revealed Middle Mesial canals with no statically significant occurrence. The frequency of isthmi in the mesial roots was 52.7%. This showed a considerable presence.

Conclusion: MM canals are 4.5% in a subpopulation of Andhra Pradesh. Isthmuses are very common in the mesial roots of permanent mandibular molars. Isthmus about 58% was seen with Type II configuration that is the presence of two canals without a definite communication.

1. Introduction

For root canal treatment to be successful, it is necessary to locate all root canals, debride them thoroughly, and seal them completely [1]. The clinician should be aware of the internal morphology of permanent teeth and the possible variations, which may be encountered [1]. The mandibular 1st Molar is the first posterior tooth that erupts, and that most often requires root canal treatment [1]. Mandibular molars often present with complex root canal anatomy.

Correspondence: *Corresponding author Email Address: *girijasajjan@vdc.edu.in*

How to cite this article: Sajjan GS, Rajashekar Ch, Madhu Varma K, Kalyan Satish R, Rishitha T, Srikanth G. Prevalence of middle mesial canals and Isthmi in mandibular molars in a subpopulation of Andhra Pradesh: an *in vivo* investigation using CBCT. Int J Dent Mater 2021;3(1): 08-15.

DOI: http://dx.doi.org/10.37983/IJDM.2021.3102

Mandibular molars usually have two roots with three or four root canals. However, several variations, such as an additional distolingual or mesiobuccal (MB) root, a C-shaped root canal system, and isthmuses connecting the canals, may also be present [2,3]. Moreover, sometimes, a third canal may be present in the isthmus between the MB and mesiolingual (ML) canal known as the middle mesial (MM) canal.

The middle mesial canal is an occasional entity that lies in the developmental groove between mesiobuccal and mesiolingual canals. Pomeranz, Eidelman, Goldberg (1981) [4] classified MM canal into three categories; a) Fin: The file passes freely between the central mesial canal (ML or MB) and the MM canal (transverse anastomosis), b). Confluent: The MM canal merges with main mesial canals in the apical third, and c). Independent: The MM canal originates as a separate orifice and ends with a separate apical foramen [4].

Root canal isthmus, a narrow ribbon-shaped communication between two root canals, is an important anatomical feature because it may contain pulp remnants, necrotic tissues, and micro-organisms and their by-products [5]. An isthmus is also called a corridor, a lateral interconnection, and a transverse anastomosis [6]. The prevalence of isthmus varies according to tooth type [7], root levels [8], and age [9]. An isthmus might be found in roots with C-shaped canals or in two adjacent canals such as mesial roots of mandibular molars, premolars, and so on [5]. The mesial root of the mandibular first Molar exhibits the most number of isthmuses [7,10].

Magnification has improved the clinician's ability to locate and negotiate unusual root canal morphology. A study on mandibular molars revealed that a Dental Operating Microscope (DOM) enhances the probability of finding and negotiating MM canals [11]. A higher-magnification view of the straight segment of the root canal by using either magnifying glasses or an operating microscope (DOM), mainly, enhances the ability to detect canals that could not usually be observed by clinical inspection alone [12]. This has increased the number of published case reports showing unsuccessful endodontic treatment because Accessory Mesial Canals are not always visible without the aid of magnification [13].

Many morphological variations in the mandibular molar are encountered in routine endodontic practice in our department. When the literature search was done, limited in vivo studies have been reported about the prevalence of the middle mesial canal. Most of the studies are present in the western population and few in South Asia. *In vitro* clearing techniques of teeth have been used in North America, Africa, East, and West Asia populations to detect the middle mesial canal. The results showed a 7-23.3% presence of the middle mesial canal. With advances in imaging, the occurrence of the middle mesial canal is reported as 46.1%.

In vivo studies utilizing radiograph, CBCT, MICRO CT, guided troughing, and use of CBCT has been used for evaluating middle mesial canals in North America, South America, Europe, and South Asia. The Presence of the middle mesial canal in the range of 4-28% is recorded. An in vivo study was done in mandibular first molars with the utilization of ultrasonic tips and endodontic explorer under a Dental Operating Microscope in the north Indian population. 28.3% of the negotiable middle mesial canal has been reported in the study.

India is a vast country; a lot of geographic variation exists along with the different ethnic populations. There are no studies done on evaluating the Presence of the middle mesial canal and isthmus in the South Indian population. Hence, a study was designed to evaluate the prevalence of the middle mesial canal in the sub-population of Andhra Pradesh.

CBCT is an advanced digital imaging system that can render the three-dimensional information of hard tissues. There is a probability of missing the middle mesial canal in two-dimensional radiograph and Endodontics without magnification. Accurate evaluation and diagnosis can be made with CBCT; hence, this study was designed to evaluate the anatomical root canal diversity in mandibular mesial roots of the subpopulation of Andhra Pradesh. The prevalence and configuration of the middle mesial canal and isthmus in mandibular mesial roots analyzed using CBCT.

2. Materials and methods

The Institutional Review-Board approved the Ethical–approval protocol. From the patient's data bank of the Oral and Maxillofacial Radiology and Department of Conservative Dentistry and Endodontics, CBCT images of permanent mandibular first and second molars were taken as a part of a dental examination for diagnosis and treatment planning purposes, from March 2018 to November 2018 were collected. Based on a previous study [4], a sample calculation was performed using 95% confidence intervals. Approximately 89 cases were needed to have a precision of 5%.

The CBCT images were taken using CRANEX 3D (Soredex, Tuusula, Finland) with a flat panel detector were collected. The scans were done at 90 kV and ten mA, as recommended by the manufacturer with different fields of view (FOV) 61×41mm, of standard resolution of 200μm voxel size with SCANORATm Imaging Software 5.2 (Soredex, Tuusula, Finland), ON-DEMAND 3DTm Server (Soredex, Tuusula, Finland). ALL images of a small field of view (FOV) CBCT with exposure parameters 60-90 kVp and 6-15 mA were selected.

The CBCT images were viewed with SCANORA Imaging Software ON-DEMAND 3D 5.2 on a Dell Professional with a 22-inch Dell light-emitting diode monitor with a resolution of 1680 x 1050 pixels in a dimly lit room. The window/level of the images was adjusted using the image processing tool in the software to ensure optimal visualization. Two independent observers, an Oral and Maxillofacial Radiologist, and an Endodontist were calibrated based on the criteria and variants established before the evaluation session. All images were analyzed simultaneously to reach a consensus for the interpretation of the radiographic findings. Multi-planar images were interactively examined sequentially in all three dimensions, and results were correlated across these images to conclude.

Only the first and second permanent mandibular molars with no previous root canal treatment and/or full-coverage restoration were included in the study. Teeth with open apices, root resorption, or calcification were excluded from the study. All teeth were analyzed using three planes (sagittal, axial, and coronal). During the examination of the teeth, the number of roots, the number of root canals in the mesial root, and the configuration of the root canal system in the mesial root were determined and recorded. In the axial view, an isthmus was recorded when a narrow ribbon-shaped communication was visualized between the MB and ML canals. The MM canal was recorded when a radiolucency with a distinct round cross-section was visualized between the MB and ML canals regardless of the presence or absence of an isthmus (Figures 1-4).

Data collected were entered in an excel sheet, and analysis was performed with the help of the Statistical Package for Social Sciences version (IBM SPSS Statistical Package for Social Sciences 20.0, USA).

Middle mesial canal

Code 0 - Absence of Middle Mesial Canal.
Code 1 - Presence of Middle Mesial Canal.

Isthmus

Code 0 - Absence of Isthmus.
Code 1 - Presence of Isthmus up to Coronal Third.
Code 2 - Presence of Isthmus up to Middle Third.

System 3 - Presence of Isthmus up to Apical Third.

CBCT images were recorded in three planes in coronal, sagittal, and axial views. In the axial view, an isthmus was recorded when narrow ribbon shape communication was visualized between mesio-buccal and mesio-lingual canal. The MM canal was recorded when a radiolucency with distinct round cross-section visualized regardless of the presence or absence of isthmus.

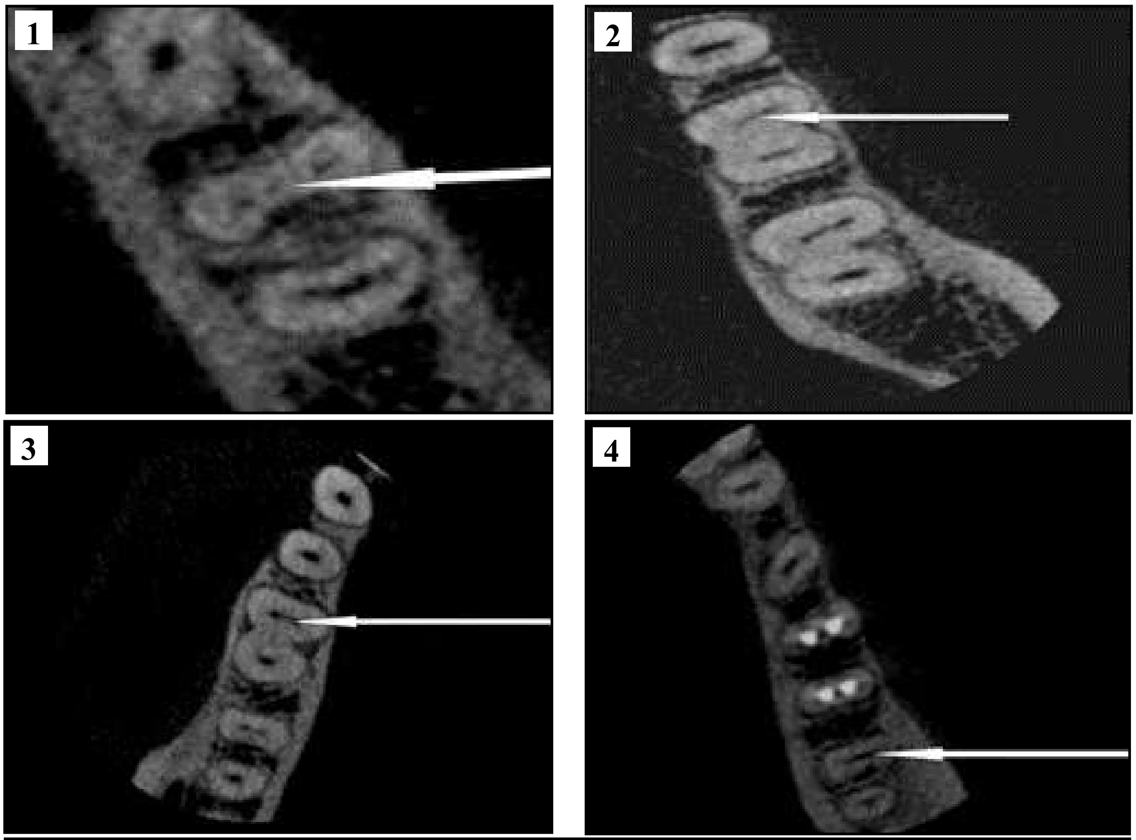
3. Results

A total of 89 CBCT images were analyzed (34 female 55 male patients). Of the 89 patients, four (4.5%) had Middle Mesial canals (Table 1). The frequency of isthmi in the mesial roots was 52.9% (Table 2). In twenty-seven molars (30.8%) isthmi were present in the coronal third, fifteen molars (16.7%) present in the middle third, four molars (5.4%) in the apical third. Prevalence of isthmi, based on the Kim classification Type II-30.3%, Type IV-16.9%, Type-V-5.4%. There was no statistically significant presence of MM canals. However, a statistically considerable Presence of isthmi in mandibular molars was seen.

4. Discussion

The success of root canal treatment primarily depends upon the complete disinfection of pulp canal space. Though there is abundant literature available regarding pulp and root canal architecture, it continues to be an enigmatic entity. Many variations exist, and one such occurrence is the middle mesial canal in a mandibular molar.

Mid mesial canal is an extra canal occurring between the mesio-buccal and mesio-lingual canal of the



Figures 1-4. CBCT images of mandibular molars. Where 1. middle mesial canal, 2. Isthmus in coronal third of mandibular molar, 3. Isthmus in middle third of mandibular molar, and 4. Isthmus in apical third of mandibular molar.

Table 1. Prevalence of middle mesial canal in mandibular molars

	Frequency	Percentage
Present	4	4.5
Not present	85	95.5
Total	89	100

Table 2. Prevalence Isthmus in Mandibular Molars

	Frequency	Percentage
Coronal 3rd	27	30.34
Middle third	15	16.85
Apical third	4	4.49
Not present	43	48.32
Total	89	100

mandibular mesial root. The middle canal orifice exists below a dentinal projection in the groove between the two main canals. The layer of dentin in this groove is lighter in colour than the adjacent dentin. Studies have reported the average length of the groove in mandibular first and second molars to be 1.07–2.81 mm and the average depth to be 1.05 mm and 0.17–7.66 mm [5].

Mid Mesial canal is an extra canal occurring between the mesio-buccal and mesio-lingual canal of the mandibular mesial root. The middle canal orifice exists below a dentinal projection in the groove between the two main canals. The layer of dentin in this groove is lighter in colour than the adjacent dentin. Studies have reported the average length of the groove in mandibular first and second molars to be 1.07–2.81 mm and the average depth to be 1.05 mm and 0.17–7.66 mm [5].

An isthmus is formed when an individual root projection is unable to close itself off, forming a constriction. The approximation of the root projections can fuse completely and form one root with one root canal system, as in the distobuccal root of maxillary molars. Alternately, partial fusion results in the formation of two root canals with an isthmus formed in between, such as the mesial root of the mandibular first Molar. No fusion leads to a large ribbon-shaped canal containing an isthmus throughout the entire root. It is a common finding in the distal root of the mandibular first molars and maxillary second premolars [10].

Many of the root canal investigations were *in vitro* studies using the clearing technique. Wang *et al.* (2010) [14] used CBCT and detected the MM canal in

2.3% of the population studied. However, these studies investigated root canal morphology only and did not aim for MM canal only. So, the prevalence of MM canals was analyzed from Vertucci's (1984) [8] classification with additional modifications. Currently, CBCT has been used in Endodontics to better understand the root canal system with the results conforming to the laboratory techniques [15,16].

The present study determined the prevalence and morphology of MM canals in permanent mandibular first and second molars based on CBCT images. In this study, scan settings of the studied CBCT images were at with different fields of view (FOV) 61×41mm and 61×78mm of standard resolution of 200μm and 300μm voxel size respectively for a clear image to investigate the root canal anatomy [17].

Geographical distribution of the middle mesial canal has been reported in Europeans, Asians, Africans, and South and North Americans. The findings of studies have also pointed to geographical differences. Nosrat *et al.* (2015) [18] found significant differences in the incidence of MMC between White (12.2%) and non-White (29.4%) patients and Brazilian and Turkish populations, respectively.

It has been shown that there is an association between untreated canals and isthmi and apical periodontitis. The untreated canals and isthmi can be covered with biofilm or even further clogged with bacteria in treated cases. Also, if not instrumented, these areas would not be reached by disinfecting irrigants [19]. Identifying the MMC isthmus with the help of CBCT and recent advances increases the success rate of root canal treatment.

In the present study, out of 89 Mandibular molars, MMC was found only in 4 (4.5%). According to Pomrerenz (1981) [4] classification in the present study, all four of the middle mesial canals are independent. In general, MM canals were classified based on Pomerenz's (1981) [4] classification as fin, confluent, and independent. The prevalence of MM canal in Asian populations was 1-13.3% [20-22]. Regarding the location of the MM canal orifice to the orifices of main mesial canals, it was found that in 4.5%of the cases, the MM canal orifice was located in the middle of the MB and ML canal orifices. These findings are inconsistent with previous studies that reported that the MM canal was located closer to the ML canal in the majority of the cases followed by the MM orifice located in the middle of MB and ML canals. In contrast, the least number of cases showed the orifice closer to the MB canal [23,24].

The management of root canal isthmus is essential in nonsurgical and surgical endodontic treatment [24]. Complete cleaning, shaping, and obturation of the apical third of root canals are considered among the most critical factors in achieving an excellent prognosis of root canal therapy. An unprepared isthmus in the root canal system, especially in the mandibular and maxillary molars, might contain necrotic debris and tissue remnants, which might serve as a reservoir for bacteria, leading to endodontic failure [7,24]. The difficulties in cleaning and shaping the mesiobuccal root canal system during conventional root canal treatment may lead to eventual failure necessitating retreatment. Therefore, initial anatomical knowledge, recognition, and proper management of an isthmus may be of great value to increase the success rate of surgical and nonsurgical endodontic treatments in posterior teeth [25-27].

In the present study, isthmuses were found in 58.9% of the mesial roots of the mandibular first and second molars. Isthmus present up to the coronal third was 30.3% middle third was 16.9%, and the apical third was 5.4% Teixeira *et al.* (2003) [28] found an incidence of 59% two canals in the mesial root of mandibular molars. Prevalence of isthmi, based on the Kim classification type2 -30.3%, type 4-16.9%, type-5-5.4%. The incidence of the isthmus was greatest 3-5 mm from the apex. In these cases, 22% were complete, and 37% partial in mandibular molars. Bidar M *et al.* (2006) [26] reported an isthmus incidence of 16% in distal roots with two canals of mandibular molars in a sample of the Iranian population.

Management of complete isthmus is more comfortable with the use of microsurgical techniques, such as the usage of a Dental Operating Microscope and microsurgical instruments. However, the preparation of incomplete isthmuses is more difficult and requires the proper use of fine ultrasonic tips [29]. A recent study found that the residual bacteria which frequently are entrapped in ramifications, isthmuses, and dentinal tubules makes it necessary to use an antibacterial irrigant and inter appointment medicament to maximize bacterial reduction before filling of the infected teeth [30].

However, the complete eradication of bacteria could not be achieved in the apical isthmus after two sessions of endodontic therapy [30]. Although various studies on the evaluation and management of isthmuses and recent advances in nonsurgical endodontic treatment modalities such as modern sonic and ultrasonic irrigation devices, side-vented needle irrigation (SNI), and VPro EndoSafe (VPro), cleaning and shaping of isthmus areas is still challenging [31,32]. Susin *et al.* (2010) [33] showed that the application of negative pressure techniques for the removal of debris from the isthmus in the mesial root of a mandibular first molar does not lead to the removal of more debris compared to the manual dynamic irrigation technique and none of the techniques completely removes debris from an isthmus [33]. Some *in vitro* studies have shown that none of the isthmuses in the root canals can be completely obturated with root-filling materials during conventional endodontic treatment [34,35]. It was shown that the production of dentinal debris during canal instrumentation and its penetration into the isthmuses of mesial root canals of mandibular molars prevent penetration of sealers and filling materials into the isthmuses despite continuous irrigation during and after instrumentation [35]. The prognosis of the root canal treatment can be predicted with this information.

A recent study by de Groot *et al.* (2009) [36] on the cleaning efficacy of laser-activated irrigation of root canals showed that this technique is more efficient in removing debris from the apical third of the root canal compared to passive ultrasonic irrigation and hand irrigation techniques. Therefore, proper management of isthmuses, including bacterial reduction and complete filling, requires future application of newer technologies and further studies to verify their efficacies.

However, CBCT has some limitations in detecting the root canal. It may be unable to show the details of the root canal system in cases where the canal is very small. MM canal is located in the sub-pulpal groove, and the canal is an additional canal that is usually smaller than the main canal. The canal may be smaller than the setting of the voxel size and, therefore, may not be detected in the image. This may affect the Presence of the MM canal in this study using CBCT images. Furthermore, CBCT is not used routinely in all cases of endodontic treatment and is considered only when further radiographic details are required for diagnosis and treatment planning.

Hence, any tooth indicated for root canal treatment should be treated with precaution. Technological advances should be used in disinfecting the enigmatic pulp space; for example, laser-activated irrigation system, which has shown better disinfection of the isthmus.

5. Conclusion

MM canals, according to the strict classification, were very rare, about 4.5% in a subpopulation of Andhra Pradesh. The clinician should be aware of the complexity of the mesial root of a mandibular Molar with the isthmus or fin between the main MB and ML canals. Isthmuses are very common in the mesial roots of permanent mandibular molars in the subpopulation of Andhra Pradesh. Isthmus, about 30.3%, was seen with Type II configuration that is the Presence of two canals without definite communication. Therefore, Dental operating microscopes and newer technologies should be used for cleaning and obturation of isthmuses to achieve higher success rates in endodontic treatment.

Conflicts of interest: Authors declared no conflicts of interest.

Financial support: None

References

1. Ballullaya SV, Vemuri S, Kumar PR. Variable permanent mandibular first Molar: Review of literature. Journal of Conservative Dentistry: JCD. 2013;16 (2):99. https://doi.org/10.4103/0972-0707.108176
2. Garg AK, Tewari RK, Kumar A, Hashmi SH, Agrawal N, Mishra SK. Prevalence of three-rooted mandibular permanent first molars among the Indian population. J Endod. 2010;36(8):1302-6. https://doi.org/10.1016/j.joen.2010.04.019
3. Reyhani MF, Rahimi S, Shahi S. Root canal therapy of a mandibular first molar with five root canals: A case report. Iran Endod J 2007;2:110-2.
4. Pomeranz HH, Eidelman DL, Goldberg MG. Treatment considerations of the middle mesial canal of mandibular first and second molars. J Endod. 1981; **7**: 565-8. https://doi.org/10.1016/S0099-2399(81)80216-6
5. Weller RN, Niemczyk SP, Kim S. Incidence, and position of the canal isthmus. Part 1. Mesiobuccal root of the maxillary first Molar. J Endod. 1995;21:380-3. https://doi.org/10.1016/S0099-2399(06)80605-9
6. Pineda F. Roentgenographic investigation of the mesiobuccal root of the maxillary first Molar. Oral Surg, Oral Med, Oral Pathol. 1973;36(2):253-60.

7. Von Arx T. Frequency and type of canal isthmuses in first molars detected by endoscopic inspection during periradicular surgery. Int Endod J 2005;38:160-8. https://doi.org/10.1111/j.1365-2591.2004.00915.x
8. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58:589-99. https://doi.org/10.1016/0030-4220(84)90085-9
9. Gu L, Wei X, Ling J, Huang X. A microcomputed tomographic study of canal isthmuses in the mesial root of mandibular first molars in a Chinese population. J Endod 2009; 35: 353-356. https://doi.org/10.1016/j.joen.2008.11.029
10. 10. Hsu YY, Kim S. The resected root surface. The issue of canal isthmuses. Dent Clin North Am. 1997;41(3):529-40.
11. Chavda SM, Garg SA. Advanced methods for identification of middle mesial canal in mandibular molars: An in vitro study. Endodontology. 2016;28(2):92. https://doi.org/10.4103/0970-7212.195425
12. de Toubes KM, de Souza Côrtes MI, de Abreu Valadares MA, Fonseca LC, Nunes E, Silveira FF. Comparative analysis of accessory mesial canal identification in mandibular first molars by using four different diagnostic methods. J Endod. 2012;38(4):436-41. https://doi.org/10.1016/j.joen.2011.12.035
13. Jacobsen EL, Dick K, Bodell R. Mandibular First Molars with Multiple Mesial Canals. 1994; 20(12): 610-613. https://doi.org/10.1016/S0099-2399(06)80088-9
14. Wang Y, Zheng QH, Zhou XD, Tang L, Wang Q, Zheng GN, et al. Evaluation of the root and canal morphology of mandibular first permanent molars in a western Chinese population by cone-beam computed tomography. J Endod 2010; 36: 1786-1789. https://doi.org/10.1016/j.joen.2010.08.016
15. Neelakantan P, Subbarao C, Subbarao CV. Comparative evaluation of modified canal staining and clearing technique, cone-beam computed tomography, peripheral quantitative computed tomography, spiral computed tomography, and plain and contrast medium-enhanced digital radiography in studying root canal morphology. J Endod 2010; 36: 1547-1551. https://doi.org/10.1016/j.joen.2010.05.008
16. Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficacy of cone-beam computed tomography as a modality to accurately identify the Presence of second mesiobuccal canals in maxillary first and second molars: a pilot study. J Endod 2010; 36: 867-870. https://doi.org/10.1016/j.joen.2009.12.023
17. Hassan BA, Payam J, Juyanda B, van der Stelt P, Wesselink PR. Influence of scan setting selections on root canal visibility with cone beam CT. Dentomaxillofac Radiol 2012; 41: 645-648. https://doi.org/10.1259/dmfr/27670911
18. Nosrat A, Deschenes RJ, Tordik PA, Hicks ML, Fouad AF. Middle mesial canals in mandibular molars: incidence and related factors. J Endod 2015; 41: 28-32. https://doi.org/10.1016/j.joen.2014.08.004
19. Ricucci D, Siqueira JF. Biofilms and apical periodontitis: study of prevalence and association with clinical and histopathologic findings. J Endod 2010;36: 1277 88. https://doi.org/10.1016/j.joen.2010.04.007
20. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. Int Endod J 2001; 34: 359-370. https://doi.org/10.1046/j.1365-2591.2001.00399.x
21. Chen G, Yao H, Tong C. Investigation of the root canal configuration of mandibular first molars in a Taiwan Chinese population. Int Endod J 2009; 42: 1044-1049. https://doi.org/10.1111/j.1365-2591.2009.01619.x
22. Karapinar-Kazandag M, Basrani BR, Friedman S. The operating microscope enhances detection and negotiation of accessory mesial canals in mandibular molars. J Endod. 2010;36(8):1289-94 https://doi.org/10.1016/j.joen.2010.04.005
23. Mannocci F, Peru M, Sherriff M, Cook R, Pitt Ford TR. The isthmuses of the mesial root of mandibular molars: a micro-computed tomographic study. Int Endod J. 2005;38(8):558-63. https://doi.org/10.1111/j.1365-2591.2005.00994.x
24. Kim S, Pecora G, Rubinstein RA. The resected root surface and isthmus. In: Color Atlas of Microsurgery in Endodontics. Philadelphia: W.B. Saunders Company; 2001. p. 98-104.
25. Rubinstein RA, Kim S. Long-term follow-up of cases considered healed one year after apical microsurgery. J Endod 2002;28:378-83. https://doi.org/10.1097/00004770-200205000-00008
26. Bidar M, Sheikhnezmi M, Moradi S. In vitro evaluation of the Presence of second canal in distal root of first and second mandibular molars. J Dent 2006;30:177-82.
27. Fan B, Pan Y, Gao Y, Fang F, Wu Q, Gutmann JL. Threedimensional morphologic analysis of isthmuses in the mesial roots of mandibular molars. J Endod 2010;36:1866-9. https://doi.org/10.1016/j.joen.2010.08.030
28. Teixeira FB, Sano CL, Gomes BP, Zaia AA, Ferraz CC, Souza- Filho FJ. A preliminary in vitro study of the incidence and position of the root canal isthmus in maxillary and mandibular first molars. Int Endod J 2003;36:276-80. https://doi.org/10.1046/j.1365-2591.2003.00638.x
29. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: A review. J Endod 2006;32:601-23. https://doi.org/10.1016/j.joen.2005.12.010
30. Vera J, Siqueira JF Jr, Ricucci D, Loghin S, Fernandez N, Flores B, et al. One- versus two-visit endodontic treatment of teeth with apical periodontitis:

A histobacteriologic study. J Endod 2012;38:1040-52. https://doi.org/10.1016/j.joen.2012.04.010

31. Johnson M, Sidow SJ, Looney SW, Lindsey K, Niu LN, Tay FR. Canal and Isthmus Debridement Efficacy Using a Sonic Irrigation Technique in a Closed-canal System. J Endod 2012;38:1265-8. https://doi.org/10.1016/j.joen.2012.05.009
32. Sarno MU, Sidow SJ, Looney SW, Lindsey KW, Niu LN, Tay FR. Canal and Isthmus Debridement Efficacy of the VPro Endo Safe Negative-pressure Irrigation Technique. J Endod 2012;38:1631-4. https://doi.org/10.1016/j.joen.2012.09.002
33. Susin L, Liu Y, Yoon JC, Parente JM, Loushine RJ, Ricucci D, *et al*. Canal and isthmus debridement efficacies of two irrigant agitation techniques in a closed system. Int Endod J 2010;43:1077-90. https://doi.org/10.1111/j.1365-2591.2010.01778.x
34. Jung IY, Seo MA, Fouad AF, Spangberg LS, Lee SJ, Kim HJ, *et al*. Apical anatomy in mesial and mesiobuccal roots of permanent first molars. J Endod 2005;31:364-8. https://doi.org/10.1097/01.don.0000145425.73364.91
35. Endal U, Shen Y, Knut A, Gao Y, Haapasalo M. A high-resolution computed tomographic study of changes in root canal isthmus area by instrumentation and root filling. J Endod 2011;37:223-7. https://doi.org/10.1016/j.joen.2010.10.012
36. de Groot SD, Verhaagen B, Versluis M, Wu MK, Wesselink PR, van der Sluis LW. Laser activated irrigation within root canals: Cleaning efficacy and flow visualization. Int Endod J 2009;42:1077-83. https://doi.org/10.1111/j.1365-2591.2009.01634.x

The effect of Fit-checking material and various subsequent cleaning methods on the wettability of the dentin surface: an *in vitro* study

VVSN Raju Jampana[1,*], Bheemalingeswar Rao D[2], Suresh Sajjan MC[2], Jitendra Babu P[3], Ramaraju AV[2], Manikyamba YJB[1]

[1]Senior Lecturer, [2]Professor, Department of Prosthodontcs and Implantology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

[3]Private Practitioner, AP Super specialty Dental Clinic, Hyderabad, Telangana, India.

INFORMATION

Article History

Received *3rd January 2021*

Accepted *1st February 2021*

Available online *22nd February 2021*

KEYWORDS

Silicone disclosing agents

Fit-checker

Wettability

Contact angle

ABSTRACT

Background: GC Fit-checker is a modified polyvinyl siloxane impression material exclusively used to check the internal fit and improve the marginal fit of indirect restorations. An unpolymerized organic film is known to be leftover on the bonding surfaces after the silicone disclosing procedure. Residual silicone film being hydrophobic may alter the wettability of the cement to the tooth/ metal surface, thus having a detrimental effect on the bond strength and retention of the restoration.

Aim: This study aimed to evaluate the wetting of luting liquid (GIC) to tooth dentin surface after application of Fit-checker and evaluate the efficiency of various surface treatments in removing the residual silicone film.

Materials and methods: Extracted human molars were mounted on the acrylic block, and the tooth occlusal surface was ground flat till the dentin exposure. All the specimens were assigned into five groups: Group 1: without application of Fit-checker (control group); Group 2: without any surface treatment after peeling off Fit-checker; Group 3: surface treatment with wet pumice; Group 4: 37% phosphoric acid treatment; Group 5: 10% polyacrylic acid treatment. Later, Type 1 Glass Ionomer Cement (GIC) liquid drop was placed on the dentin and photographs were made horizontally using a standardized procedure. Contact angles were measured using AUTOCAD software. Obtained values were statistically analyzed using the One-way ANOVA test and Tukey's Post hoc test. Samples of each group were examined using the scanning electron microscope.

Results: Statistically significant difference was observed among all the groups except between Group 4 and Group 2 ($p > 0.05$). SEM images of various groups showed a significant difference in roughness patterns.

Conclusion: Surface treatment with pumice and the rotary brush was an effective method among the three in cleaning the residual silicone film.

1. Introduction

The fit of indirect restoration and maintenance of optimum cement space (25μm) can be affected by various irregularities/interferences on the internal surface of the casting [1,2]. These interferences can be identified using Fit-checking material and eliminated by the selective grinding procedure [3]. Fit-checking material (GC Fit-checker) is a modified polyvinyl siloxane material exclusively used to

Correspondence: *Corresponding author Email Address: *dr.rajujampana@gmail.com*

How to cite this article: Jampana VVSNR, Bheemalingeswar Rao D, Suresh Sajjan MC, Jitendra Babu P, Ramaraju AV, Manikyamba YJB. The effect of Fit-checking material and various subsequent cleaning methods on the wettability of the dentin surface: an in vitro study. Int J Dent Mater 2021;3(1): 16-23.

DOI: http://dx.doi.org/10.37983/IJDM.2021.3103

check the internal fit and improve the marginal fit of the restorations [4]. The silicone disclosing procedure using Fit-checker leaves a thin layer of residual unpolymerized organic film on bonding surfaces [5]. Residual silicone film being hydrophobic alters the wettability of the cement to the metal surface [5].

During the luting procedure, the GIC cement flows (wetting) between the irregularities of both tooth and the internal surface of the restoration and results in micromechanical bonding between restoration and luting cement interface and chemico-mechanical bonding between tooth and luting cement interface. This adhesion results in enhanced bond strength between the cement to the restoration and the tooth, respectively [2].

The contact angle is an indicator of the flow of liquid on a solid surface. A lower contact angle indicates better wetting of the tooth/restoration surfaces by the luting agent that improves the adaptation. Thus, it enhances the bond strength and retention of the indirect restorations [2]. After peeling off the Fit-checker, a thin layer of residual silicone film will be leftover on the restoration's internal surfaces. It acts as a barrier and prevents bonding between restoration-cement interface. Numerous researches reported that there would be a decrease in retention efficacy and tensile bond strength after Fit-checker application [6-8]. Studies have shown that the residual silicone film on the metal surface can be treated by various mechanical and chemical means. These surface treatments remove the silicone film and increase the tensile bond strength [6-8]. During the silicone disclosing procedure, apart from the restoration's internal surface, Fit-checker also makes contact with the prepared tooth. However, the literature does not provide any evidence that Fit-checker residue on the tooth. Hence, it was hypothesized that Fit-checker tends to leave a residue on the tooth also.

The present in-vitro study was conducted to measure and compare the contact angle of GIC liquid on dentin surfaces treated with the application of Fit-checker and various surface treatments to eliminate the residual silicone layer of Fit-checker. The study's null hypothesis was that all the surface treatments used in this study could not effectively remove the residual film.

2. Materials and methods

A total of 75 extracted molar teeth with adequate occlusal table width and without dental caries were collected and stored in 10% neutral buffered formalin.

2.1 Sample preparation

Each tooth was mounted into an acrylic block to support and position the occlusal surface parallel to the floor. The occlusal surface of the tooth was ground with a diamond disk to remove the enamel and expose the dentin. Dentin surface was considered for the study as most tooth preparations for crown fabrication clinically exposes the tooth dentin surface. Care was taken to make the prepared occlusal surface flat and parallel to the platform. This was verified using a bubble gauge placed over the flat occlusal dentin surface. All the specimens (Figure 1) were prepared similarly. Randomization of samples was done. Specimens were divided into five groups.

Group 1: Without the application of Fit-checker (n=15) (Control group).

All the remaining specimens were applied with a layer Fit-checker (GC Corporation, Tokyo, Japan), and it was peeled off after two minutes of setting. Thus, prepared specimens were randomly divided into four groups.

Group 2: No surface treatment after peeling off Fit-checker (n=15)

Group 3: Surface treatment using Wet Pumice and polishing brush for 10 sec (n=15)

Group 4: Surface treatment using 37% Phosphoric acid for 15 sec (n=15)

Group 5: Surface treatment using 10% Polyacrylic acid for 20 sec (n=15).

2.2 Surface treatments

In group 3, the Surface was treated with pumice slurry (Pumice powder, Vishal Dentocare Pvt. Ltd, Ahmedabad, Gujarat, India) and polishing brush running at low speed for 10 seconds. In group 4, a standard etchant gel of 37% Phosphoric acid (Acid Etching gel, Nimai Dento, Muzaffarnagar, India) was applied on the dentin surface and washed off after 15 seconds. In group 5, three drops of 10% Polyacrylic acid (Dentin conditioner, GC Corporation, Tokyo, Japan) was applied to the whole surface and washed after 20 seconds. All the surface treated samples were subjected to water wash using a two-way syringe for 5 seconds after their respective treatment and dried with blotting paper.

An acrylic device was custom fabricated to standardize the distance of the liquid drop. This device was connected to the analyzing rod of the surveyor. The acrylic block has a hole in its center with a diameter equal to the GIC type I liquid bottle. A 21-gauge needle was attached to the GIC liquid bottle's nozzle to reduce the liquid drop size. The GIC liquid bottle was inverted and placed in the central hole of the acrylic resin block and was held parallel to the analyzing rod of the surveyor. This entire assembly resulted in providing the dentin surface perpendicular and 10mm away to the position of the liquid bottle. The bottle was gently squeezed to release a drop of liquid in the center of the specimen (Figure 2). Only luting GIC liquid was used in the study as it was technique sensitive to handle the mixed cement to dispense the drop.

2.3 Measurement of contact angle:

A horizontal view of the specimens with the liquid drop was captured using a DSLR camera (Nikon D 3200) and a 90mm macro lens (NIKON Corp., Japan) (Figure 3). The camera was held at the level of the liquid drop and tooth occlusal interface using a tripod. The distance between the specimen and the lens was standardized to 10 cm. The captured images were saved as JPEG images. The images were opened in AUTOCAD software (2010 Autodesk, Inc., Nasdaq: ADSK). A line was digitally drawn on the image along the base of the liquid drop on the tooth occlusal interface extending up to the three-phase (liquid, solid, air) boundary. One more line was digitally traced on the image along the outer surface of the liquid drop extending up to the three-phase boundary. The contact angle was measured at the intersection of the two lines in all the groups (Figure 4-8). A flat dentin surface without irregularities was considered to measure the contact angle as it is difficult to measure the contact angle on a regular clinical tooth preparation design. The obtained data were statistically analyzed using the Statistical Package for Social Sciences 21.0, USA. ANOVA test and Tukey HSD were used to compare the significant difference in mean contact angle values between the groups. The correlation was considered significant at $P<0.05$.

2.4 Scanning Electron Microscopic (SEM) analysis

One sample from each group was randomly chosen for SEM analysis. The samples were subjected to gold sputtering and observed under Scanning Electron Microscope (S 3700N, Hitachi, USA). Images were captured at 200X and 2000X magnification (Figures 9-18).

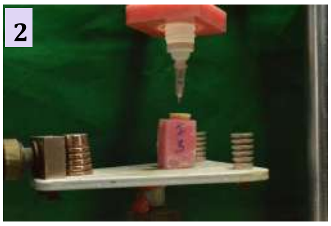
3. Results

The mean contact angles of all the groups are given in table 1. Group 2 exhibited the maximum mean contact angle followed by group 4, 5 and 3. Group 1 showed less contact angles. The specimens with no application of Fit-checker showed the least contact angles. The specimens treated with Fit-checker and no subsequent surface treatments resulted in increased contact angle. The samples treated with various agents decreased the contact angle compared to the specimens that did not treat after the removing the Fit-checker. However, the specimens with no Fit-checker application displayed the least contact angles compared to the surface-treated specimen groups. One-way ANOVA showed a statistically significant difference ($p=0.000$) among the groups (Table 1). Intergroup comparison using Tukey HSD showed a statistically significant difference ($p=0.000$) between all the groups except between Group 2 and Group 4 ($p=0.639$) (Table 2).

SEM images of specimens before (Group1) and after the Fit-checker application (Group 2) showed a marked difference in roughness patterns. SEM evaluation of Group 3 exhibited less roughness pattern compared to Group 1, but it is more compared to Group 2. SEM evaluation of Group 4 showed no appreciable difference in the roughness of dentin surface compared to Group 1. SEM evaluation of the samples of Group 5 showed reduced roughness of dentin compared to Group 2 and increased roughness compared to Group 1.

4. Discussion

Fit-checking material (GC Fit-checker) is a modified polyvinyl siloxane material exclusively used for checking the internal fit of the indirect restorations. Silicone disclosing material is popularly used to identify and correct the seating interferences as it significantly reduce the marginal opening from 387μm to 97μm and provided 70% improvement in marginal seating [1,6,9]. Verification of the internal fit of indirect restorations using Fit-checker application includes coating the silicon material to the internal surface of the restoration followed by seating on dies or intraorally on the abutment teeth [1]. Once the Fit-checker sets, the restoration's internal surface should be inspected for exposed areas of the restoration. These areas can be subjected to selective grinding to eliminate interferences [1,4]. Assessment of cement space can also be done by measuring the thickness of set silicone film.



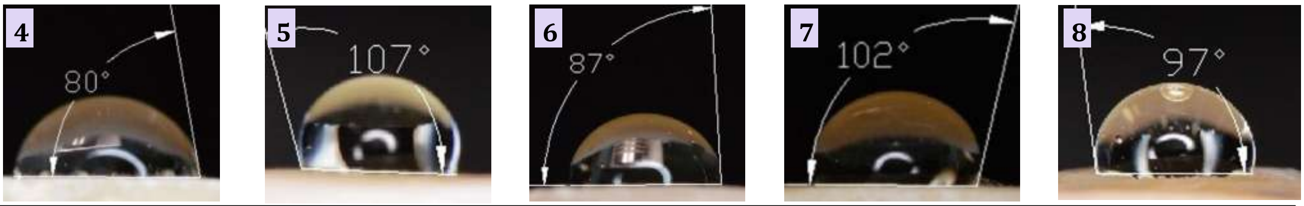
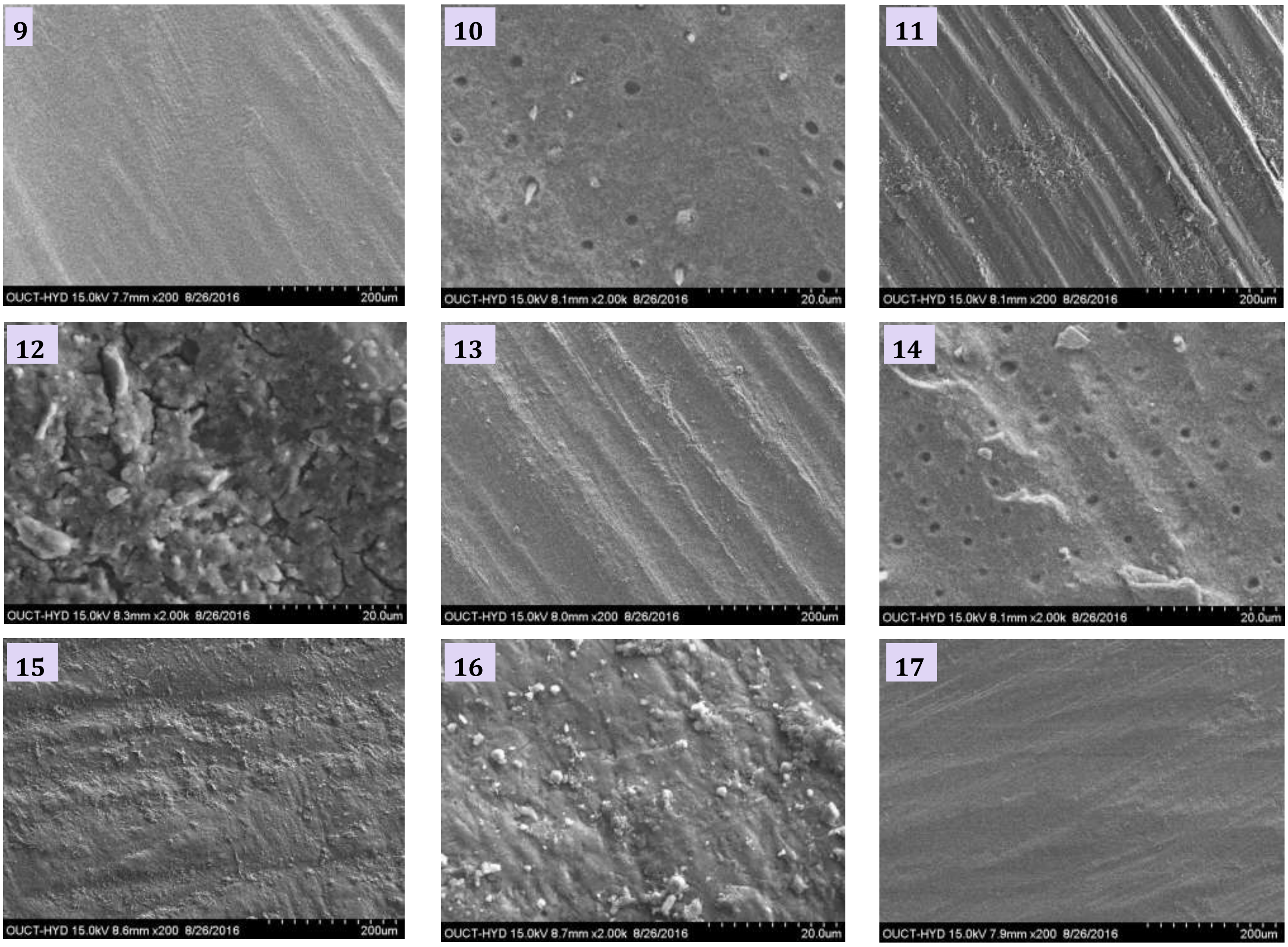


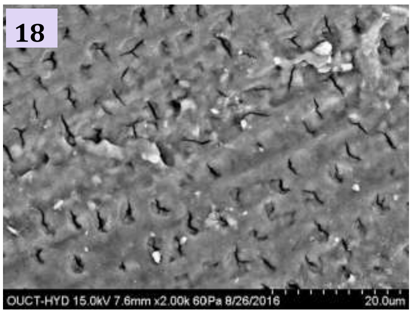
Figure1. Natural teeth embedded in acrylic blocks.

Figure 2. Assembly for placing a liquid drop on specimen from 10mm height.

Figure 3. Position of camera from 10 cm from specimen for making photographs of drop.

Figures 4-8. Contact angle measured using AUTOCAD software. Where figures 4, 5, 6, 7 and 8 are contact angles measured in group 1, 2, 3, 4, and 5, respectively.





Figures 9-18. SEM images of the specimens from various groups. Where figures 9, 11, 13, 15 and 17 are SEM images at the magnification of 200x from groups 1, 2, 3, 4, and 5, respectively; and figures 10, 12, 14, 16, and 18 are are SEM images at the magnification of 2000x from groups 1, 2, 3, 4, and 5, respectively

Table 1. Comparison of contact angle (mean and standard deviation) of the groups using One-Way ANOVA.

Groups	Mean	Standard Deviation	F-value	Significance (p – value)
Group 1	82.1667	2.66369	98.525	0.000
Group 2	107.3667	4.09035		
Group 3	90.5667	4.83982		
Group 4	105.3000	3.98121		
Group 5	98.1333	4.51374		

Table 2. Inter-group comparison of contact angles of the groups using Tukey HSD

Groups		Mean Difference	Standard Error	Significance
Group 1	Group 2	25.200*	1.492	0.000
	Group 3	8.400*	1.492	0.000
	Group 4	23.133*	1.492	0.000
	Group 5	15.966*	1.492	0.000
Group 2	Group 3	16.800*	1.492	0.000
	Group 4	2.066	1.492	0.639
	Group 5	9.233*	1.492	0.000
Group 3	Group 4	14.733*	1.492	0.000
	Group 5	7.566*	1.492	0.000
Group 4	Group 5	7.166*	1.492	0.000

Fit-Checker (GC Co., Tokyo, Japan) is a chemically stable silicone. Hence, it is claimed by the manufacturer that no residue will be left on the internal surface of the restoration. However, X-ray photoelectric spectroscopy (XPS) observation on Zirconia specimens after using Fit-checker has revealed the presence of Si, C, and O2 on the surface [5]. This unpolymerized organic film has shown to interfere in the bonding of cement to the internal surface of restoration [10-12]. Some investigators presumed that chemical reactions and covalent bonds might occur between silicone indicator films and restorations, leading to a stable adherence of silicone to bonding substrate and alter the surface characteristics of metal upon removal [5].

The mode of adhesion of glass ionomer cement (GIC) to the tooth surface is chemico-mechanical. The wettability of the liquid cement to the tooth/ restoration surfaces enhances the flow of the cement into the irregularities on both surfaces and ensures adhesion. The residual silicone film being hydrophobic found to alter the wettability of the cement to the metal surface [2]. A lower contact angle is desired for luting agents to ensure uniform flow and better bonding. Many techniques have been tried to clean the metal and ceramic surfaces contaminated with the silicone residues [7,8,12-14].

Various authors had found a considerable reduction of retention of 10.02 MPa to 4.85 MPa when the restorations were treated with disclosing agents like wax and silicone [7,12]. Methods used to clean ceramic surface post-Fit-checker removal have significantly influenced the resin-ceramic bond strength. The most effective method was air abrasion compared to cleaning procedures using steam cleaning, phosphoric acid and isopropanol [7,12].

Numerous studies have discussed cleaning procedures for silicon residue on metal and ceramic surfaces [4-12]. Since there is no evidence of residue on the tooth surface in the literature, the present study was conducted on dentin surface to find out the contact angle of GIC cement liquid prior to Fit-checker application and after the application.

In the present study, a significant increase in the mean contact angle was observed in Group 2 compared to Group 1 (Table 2). This can be attributed to the residual silicone film, which was leftover on the dentin surface by the Fit-checker. This is in accordance with the previous studies, which have demonstrated an increase in contact angle, and the residue was also leftover on the restorations [4,5,7,10,14]. SEM images of specimens before (Figures 9,10) and after the Fit-checker application (Figures 11,12) showed a marked difference in roughness patterns. This indicates that Fit-checker has left a residual film on the dentin surface.

In the literature, various agents have been used to remove the smear layer from the dentin surface to enhance the chemical-mechanical bonding between adhesive luting cement and the dentinal matrix. In the present study, some of the most commonly used agents like wet pumice, 37% phosphoric acid, 10% polyacrylic acid were used. These agents have proven their effectiveness in removing the smear layer containing both organic and inorganic contents [15]. Hence, these acids were used in the present study to evaluate their capability of removing the Fit-checker residue from the tooth surface.

The dentin surface treated with wet pumice (Group 3) showed a statistically significant (p=0.000) decrease in mean contact angle (Table 2) compared to treating with the other agents. The pumice treatment improved the wettability denoting the removal of silicone contaminants. However, compared to the control group, the mean contact angle was significantly increased, proving the limitation of the cleaning procedure in eliminating the contaminant. SEM evaluation of Group 3 (Figures 13,14) suggested less roughness pattern compared to Group 1 (Figures 9,10). But it is more compared to Group 2 (Figures11,12). This indicates that the surface treatment using wet pumice and brush for 10 seconds might have mechanically abraded and removed silicone film to a greater extent; however, the silicon residue may not have completely eliminated.

No statistically significant increase in the mean contact angle (p=0.639) was observed in Group 4 compared to Group 2 (Table 2). SEM evaluation of Group 4 (Figures 15,16) showed no appreciable difference in dentin surface roughness. This indicates that cleaning with 37% phosphoric acid did not effectively remove residual silicone film. Although phosphoric acid effectively cleaned the smear layer [16 -24], the silicone residue was not completely removed from the restoration surfaces.

In the present study, a statistically significant decrease in the mean contact angle was observed in Group 5 compared to Group 2 (Table 2). This indicates that 10% polyacrylic acid (GC Dentin conditioner) is partially effective in cleaning the silicone residue on the specimens. A statistically significant increase in the mean contact angle (p=0.000) was observed in Group 5, compared to Group 1 (Table 2). SEM evaluation of the samples of Group 5 (Figures 17,18) showed reduced roughness of dentin compared to Group 2 (Figures 11,12) and increased roughness compared to Group 1 (Figures 9,10). Although polyacrylic acid can effectively clean the smear layer [18-22,25-28], the silicone residue was not removed completely from the restoration surfaces.

In this present study, a statistically significant decrease in the mean contact angle (p=0.000) was observed in Group 3, compared to Group 5 (Table 2). This was also supported by SEM (Figures 13,14 & 17,18). It can be observed that mechanical cleaning with pumice and brush was more effective than chemical cleaning with 10% polyacrylic acid. Polyacrylic acid seems to be more effective with the removal of the smear layer than silicone residue. In the present study, 10% polyacrylic acid (GC dentin conditioner) was used and possibly the low concentrations can be attributed to the low effectiveness.

Statistically significant decrease in mean contact angle (p=0.001) in Group 4 compared to Group 5 (Table 2) shows that chemical cleaning with 10% polyacrylic acid for 20 seconds was more effective than 37% phosphoric acid for 15 seconds. However, in the literature, 37% phosphoric acid was more effective in removing the smear layer [21,22]. Even though phosphoric acid and polyacrylic acids were effective in removing the smear layer, which is a combination of inorganic and organic matter, they were not effective enough to remove the residual silicone film organic in nature. In the present study, 10% Polyacrylic acid removed the silicone residue to a lesser extent, whereas 37% phosphoric acid was not effective in removing the residue. This may be due to the nature and strongness of acid and the time for which it was applied. The null hypothesis of the study was partially accepted.

Clinical significance: Whenever silicone disclosing procedure is used for checking the fit of the indirect restorations, wet pumice cleaning with a polishing brush can be used as a cleaning procedure on the dentin prior to cementation of the prosthesis to enhance the retention of the prosthesis.

Though SEM evaluation was considered an effective adjunct, quantification of surface roughness could have brought more insight. Further studies can be done to evaluate the effect of other cleaning agents in removing the residual silicone film and also to evaluate the effect of residual silicone film on the shear bond strengths between luting cement and the dentin surface.

5. Conclusion

From this study, the following conclusions can be drawn;

a. The residue of the Fit-checker significantly reduced the wettability of the tooth dentin surface to GIC type 1 liquid.
b. Among the three surface treatments, mechanical surface treatment using wet pumice and the rotary brush was more effective in removing residual silicone film followed by polyacrylic acid (10%). Phosphoric acid (37%) was the least effective.

Conflicts of interest: The declared no conflicts of interests.

Financial Support: None.

References

1. Sorensen JA. Improved seating of ceramic inlays with a silicone fit-checking medium. J Prosthet Dent. 1991; 65(5):646-9. https://doi.org/10.1016/0022-3913(91)90199-7
2. Anusavice KJ. Phillip's Science of Dental Materials. 11th ed., W. B. Saunders Company. 2003: 295-350.
3. Rissin L, Wetreich G. Utilization of elastomeric impression materials to evaluate the accuracy of cast restorations prior to cementation. J Prosthet Dent. 1983; 49(4): 585-6. https://doi.org/10.1016/0022-3913(83)90332-3
4. Szep S, Schmid C, Weigl P, *et al.* Effect of silicone disclosing procedure on the shear bond strength of composite cements to ceramic restorations. J Prosthet Dent. 2003; 89(1):60-5. https://doi.org/10.1067/mpr.2003.1
5. Yang B, Wolfart S, Scharnberg M, *et al.* Influence of contamination on zirconia ceramic bonding. J Dent Res. 2007; 86(8): 749-53. https://doi.org/10.1177/154405910708600812
6. White SN, Sorensen JA, Kang SK *et al*. Improved marginal seating of cast restorations using a silicone disclosing medium. Int J Prosthodont. 1991; 4(4): 323 -6.
7. Hammad IA, Amir MA. The effect of two fit-indicating materials and various subsequent cleaning methods on the retention of simulated crowns. J Prosthet Dent. 2008; 99: 46-53. https://doi.org/10.1016/S0022-3913(08)60008-6
8. Klosa K, Walfart S, Lehmann F *et al.* The effect of storage conditions, contamination modes and cleaning procedures on the resin bond strength to lithium disilicate ceramic. J Adhes Dent. 2009; 11: 127-35.
9. Davis SH, Kelly JR, Campbell SD. Use of elastomeric material to improve the occlusal seat and marginal seal of cast restorations. J Prosthet Dent. 1989; 62(3): 288-91. https://doi.org/10.1016/0022-3913(89)90334-X
10. Millstein PL, Ho JC, Naim W *et al.* Effect of a silicone fit-indicator on crown retention in vitro. J Prosthet Dent 1989;62(5):510-1. https://doi.org/10.1016/0022-3913(89)90068-1
11. Pohjola RM. Fit checker for all ceramic restorations. Oper Dent. 2003; 28: 346.
12. Quaas AC, Yang B, Kern M. Panavia F 2.0 bonding to contaminated zirconia ceramic after different cleaning procedures. Dent Mater. 2007; 23: 506-12. https://doi.org/10.1016/j.dental.2006.03.008
13. Zhang S, Kocjan A, Lehmann F *et al.* Influence of contamination on resin bond strength to nano-structured alumina-coated zirconia ceramic. Eur J Oral Sci. 2010; 118: 396-403. https://doi.org/10.1111/j.1600-0722.2010.00752.x
14. Jyothi M, Reddy V, Shetty J *et al.* Effect of fit checking materials and subsequent cleaning methods on the contact angle of luting agents–a pilot study. Trends in Prosthodontics and Dental Implantology. 2012; 3(2): 38-40.
15. Bowen RL, Eick JD, Henderson DA *et al.* Smear layer: removal and bonding consideration. Oper Dent. 1984; suppl. 3: 30 – 4.
16. Meryon SD, Tobias RS, Jakeman KJ. Smear removal agents: A quantitative study in vivo and in vitro. J Prosthet Dent. 1987; 57(2): 174-9. https://doi.org/10.1016/0022-3913(87)90142-9
17. Toledano M, Osorio R, Perdigao J. *et al.* Effect of acid etching and collagen removal on dentin wettability and roughness. J Biomed Mater Res. 1999; 47:198–203. https://doi.org/10.1002/(SICI)1097-4636(199911)_47:2<198::AID-JBM9>3.0.CO;2-L
18. Tay FR, Smales RJ, Ngo H, *et al.* Effect of Different Conditioning Protocols on Adhesion of a GIC to

Dentin. J Adesive Dent. 2001;3:153-67.

19. Banomyong D, Palamara JEA, Burrow MF, Messer HH. Effect of dentin conditioning on dentin permeability and micro-shear bond strength. Eur J Oral Sci. 2007; 115: 502–9. https://doi.org/10.1111/j.1600-0722.2007.00483.x
20. Parihar N, Pilania M. SEM evaluation of effect of 37% phosphoric acid gel, 24% EDTA gel and 10% maleic acid gel on the enamel and dentin for 15 and 60 seconds: an in-vitro study. IDJSR. 2012;1(2):39-41.
21. Mauro SJ, Sundfeld RH, Bedran-Russo AKB, *et al.* Bond strength of resin-modified glass ionomer to dentin: the effect of dentin surface treatment. J Minim Interv Dent. 2009; 2 (1):45-53.
22. Poggio C, Beltrami R, Scribante *et al.* Effect of different surface treatments on shear bond strength of glass-ionomer cements. Annali di Stomatologia. 2014;5(1):15-22. https://doi.org/10.11138/ads/2014.5.1.015
23. Bagmar S, Jadhav S, Hegde V *et al.* A comparative evaluation of the efficiency of different acids for removal of smear layer after cavity preparation. An *in vitro* study. IJRANSS. 2013; 1(2): 5-12.
24. Gateva N, Gusyiska A, Stanimirov P, *et al.* Effect of etching time and acid concentration on micromorphological changes in dentin of both dentitions. J of IMAB. 2016; 22(2) ;1099-110. https://doi.org/10.5272/jimab.2016222.1099
25. Berry EA, Von der Lehr WN, Herrin HK. Dentin surface treatments for the removal of the smear layer: an SEM study. J Am Dent Assoc. 1987; 115: 65-7. https://doi.org/10.14219/jada.archive.1987.0202
26. Hewlett, ER, Caputo AA, Wrobel DC. Glass ionomer bond strength and treatment of dentin with polyacrylic acid. J Prosthet Dent. 1991;68(6):767-72. https://doi.org/10.1016/0022-3913(91)90412-P
27. Shashirekha. G, Jena A, Hegde J. Bond strength of light activated glass ionomer with different conditioners on human dentin. IJSTR. 2012; 1(9):26-9.
28. Anne G, Manne P, Kadiyala KK, Chiramana S, Oliganti SHB, Boppana PP. A comparative study to evaluate retention of full metal crowns cemented with various luting agents with and without application of dentine conditioners: An *in vitro* study. J NTR Univ Health Sci. 2016;5: 29-33. https://doi.org/10.4103/2277-8632.178975

Review Article International Journal of Dental Materials 2021; 3(1) ISSN: 2582-2209

Management of dental office during COVID-19 Pandemic

Sri Sowmya K[1,*], Ravi Kumar C[2], Sujesh M[2], Pavani Lukka[3]

[1]Postgraduate Student, [2]Professor, [3]Senior Lecturer Mamata Dental College, Giri Prasaad Nagar, Khammam, Telangana, India -507002.

INFORMATION

Article History

Received 15th *September 2020*

Received revised *29th December 2020*

Accepted *12th January 2021*

Available online *22nd February 2021*

KEYWORDS

COVID-19

Infection control

Patient management in dental clinics

ABSTRACT

Novel Coronavirus (COVID-19) is a deadly protein molecule devastating the humankind and has brought down the life to a standstill. Its effect is determined by the interaction among the agent, the host and the environment. The proven fact that the spread of COVID-19 is air-borne has made it mandatory for the dental fraternity to follow a systematic protocol in clinical practice. A proper history of travel and exposure, thermal scanning, symptoms of sore throat, dry cough and difficulty in breathing makes you suspect an individual with COVID-19. It is imperative to consider only emergency and essential dental procedures to be carried out under strict aseptic measures, not only for suspects but also for routine patients.

COVID-19 and dentistry are very closely related to each other as the dental professionals are directly working in the oral cavity. Although the Ministry of Health & Family Welfare has issued comprehensive guidance to prevent the occurrence of hospital-acquired infection (HAI) in health facilities, the practice of universal precautions might still be lacking in many dental professionals due to improper knowledge. Data acquisition was carried out using the keywords, COVID-19, control of infection, and patient management in dental offices in PubMed, Medline, ProQuest, etc., electronic databases. There was also a manual scan of many journals and books, and highly relevant papers were considered for the present study.

1. Introduction

Because of the SARS-CoV-2 outbreak, the dental fraternity is undergoing a dramatic transition and will continue to do so over the coming weeks and months. The implications, particularly for the dental community and patients seeking dental care, are far-reaching and unpredictable. A National Institute of Health (NIH) study found that SARS-CoV-2-containing aerosols remain infectious for up to 3 hours in enclosed spaces, four hours on copper, 24 hours on card-board, and three days on stainless steel and plastic. During dental care, the use of an ultrasonic scaler, a triple syringe, dental handpiece, and other high-speed powered tools will produce substantial quantities of aerosols, placing dental practitioners, dental teams, and their patients at high risk of COVID-19 [1].

2. Structure of novel Coronavirus

The 2019 novel coronavirus (2019-ncov) has spread rapidly to the rest of the world from its roots in Wuhan City, Hubei Province of China. [2]. On 11 February 2020, the World Health Organization (WHO) declared the epidemic disease

Correspondence: *Corresponding author Email Address: sowmyavarmakalidindi@gmail.com

How to cite this article: Kalidindi SS, Ravi Kumar C, Sujesh M, Lukka P. Management of dental office during COVID-19 Pandemic. Int J Dent Mater 2021;3(1): 24-32. *DOI: http://dx.doi.org/10.37983/IJDM.2021.3104*

effected by 2019-ncov as coronavirus disease (COVID-19).

Coronavirus is a huge group of viruses that cause ailments ranging from the common cold to more infectious complications such as Middle East Respiratory Syndrome (MERS-Cov) and severe acute respiratory syndrome (SARS-Cov). Coronaviruses spread from animals to humans (zoonotic) [3,4]. Coronaviruses are huge, ranging from 60 nm to 140 nm in diameter [5], encased, positive-stranded RNA viruses. They have a gigantic genome among all RNA viruses. The genome is filled inside a helical capsid formed by the nucleocapsid protein and encircled by an envelope. Analogous with the viral envelope are three structural proteins: the membrane protein and the envelope protein are entangled in virus assembly, whereas the spike protein (S-protein) regulates virus entry into host cells and forms huge protrusions from the virus surface among the structural proteins, giving coronaviruses the illusion of having crowns (hence their name; corona, in Latin, means crown). The spike is an important stimulus of viral host range and tissue tropism as well as a significant inducer of host immune responses, apart from controlling the virus entry (Figure1).

Coronavirus causes respiratory, gastrointestinal and central nervous system diseases in humans and other animals, alarming human health from mild upper to lower respiratory tract infections [3].

The SARS-cov-2 is a recent strain of coronavirus that was first noticed in Wuhan's city, in the Hubei province. SARS-cov-2 primary origin is still unmapped, although the earlier cases were linked to the Wuhan city's Huanan seafood market [6].

Of late, several studies have advocated that bats may be the possible natural host of SARS-Cov-2 [7]. The whole genome-wide nucleotide sequence of SARS Cov-2 is 96% identical to a bat CoV. Notably, SARS-CoV-2 has been sequestered from pangolins, and it was found to have -85.5-92.4% similarity to SARS-cov-2, suggesting that pangolin may be a potential intermediate host for SARS-cov-2.

3. Transmission route of SARS-cov-2

The SARS cov-2 communicate between humans via respiratory droplets, Close Contact, direct or indirect contact with mucous membranes in the eyes, mouth or nose [8], aerosol transmission in a relatively closed environment with constant vulnerability to high concentrations of aerosol. Moreover, it has been outlined that COVID-19 patients have some gastrointestinal symptoms, including diarrhoea, nausea and vomiting (Figure 2) [9].

Dental professionals are more vulnerable to COVID-19 infection due to close face-to-face contact [10]. Therefore, a dental professional must cease the regular treatments and treat only the emergency cases to limit the spread of COVID-19 among their patients and beyond.

This virus's spread is commonly seen in household contacts, health care professionals not wearing personalised protective equipment (PPE) and in closed settings like social or work gatherings. Extensive SARS -cov-2 pestilence of environmental surfaces in hospital wards of patients with COVID-19 has been described [2].

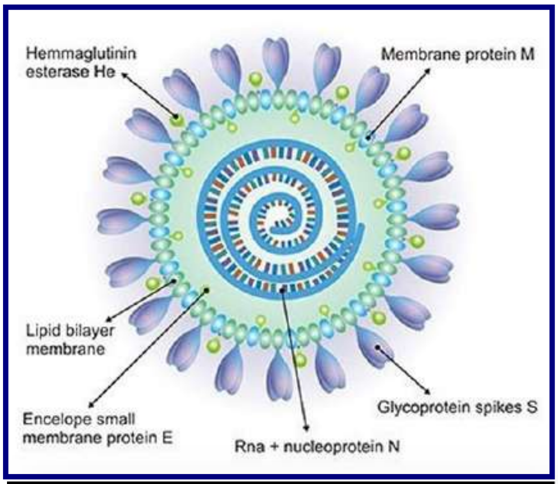


Figure 1. Structure of SARS – CoV virus.

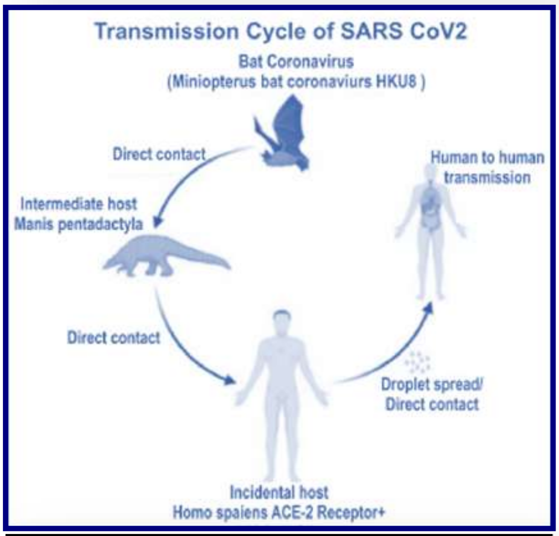


Figure 2. Transmission cycle of SARS-CoV - 2 .

3.1 Period of infectivity

According to a modelling study in China [11], the covid -19 has a mean survival interval of 5-8 days between the onset of symptoms. The infection starts 2-3 days prior to symptom onset, peaked 07 days before symptom onset, and declined within seven days [12]. Transmission of virus has also been reported from asymptomatic individuals within the incubation period [12].

3.2 Clinical features

Clinical features and symptoms of Covid-19 are described in tables 1 and 2 respectively [13].

4. Preventive measures

- Social Distancing - maintaining a distance of one meter (3 feet) between two individuals at all times.
- Regularly and thoroughly cleaning hands with alcohol-based hand rub and washing with soap and water. Avoid touching face, nose or eyes.
- ***Respiratory hygiene:*** Covering mouth and nose with a cloth/tissue or bend an elbow while coughing and sneezing. Dispose of the used tissue immediately into a covered dustbin operated by foot. Home quarantine and self-isolation.
- Keep up-to-date information using official government portals [14].

5. General implications of COVID-19 on global dental practice

Many countries have shut down routine dental care in a similar way to China. But many dental clinicians reduced routine dental care for fear of spreading COVID-19 among their patients and others [15]. Therefore, dentists need to optimise preventive strategies by focusing on patient positioning, hand hygiene, and all PPE to avoid COVID-19 infection. The pre-check triages established in clinics and hospitals to record the temperature of every staff and patient. Preoperative antimicrobial mouth-rinse provided for every patient to reduce the bacterial load. Use of rubber-dam and high-volume suctions during a dental emergency procedure. Separate entry gates for patient and dentist along with the use of PPE (Figure-3) [16].

5.1 Treatment categorization

To develop these guidelines, it is proposed to divide dental procedures into five categories (Table 3, Figure. 4).

Figure 3. Model of dental setup during coronavirus infection outbreak .

A. Emergency management of life-threatening conditions.
B. Urgent conditions that can be managed with minimally invasive procedures and without aerosol generation.
C. Urgent conditions that need to be managed with invasive and/or aerosol-generating procedures.
D. Non-urgent procedures.
E. Elective procedures.

6. Guidelines for Reopening Dental Offices Safely During the COVID-19 Pandemic

These practices are designed to protect dentists, dental health care personnel (DHCP) and prevent DHCP from spreading infections among patients. Standard precautions include [18];

- Hand hygiene.
- Personal protective equipment (for example, gloves, masks, eyewear).
- Respiratory hygiene/cough etiquette.
- Sharps safety (engineering and work practice controls).
- Secure injection procedures (i.e., aseptic parenteral drug technique).
- Sterile instruments and devices.
- Clean and disinfected environmental surfaces.

6.1 Personal Protective Equipment

Considering those asymptomatic patients, COVID-19 can still be contagious, and it should be assumed that all patients may transmit the disease. To mitigate the chances of exposure, use the maximum available amount of PPE while treating patients. Dentists should exercise their own clinical judgment and cautiously

Table 1. Clinical features of COVID-19 [14]

Spectrum	Clinical presentation
Mild	No pneumonia.
Moderate - severe	Dyspnea, hypoxia, >50% involvement of lung on imaging within 24- 48 hours.
Critical	Respiratory failure, shock, multiorgan dysfunction.

Table 2. Symptoms COVID-19 [14]

Common symptoms	Less common symptoms	Rare symptoms
Fever	Myalgia/arthralgia	Nausea, vomiting
Cough	Head ache	Nasal congestion
Fatigue	Sore throat	Diarrhoea
Shortness of breath	Chills	Palpitations and chest tightness

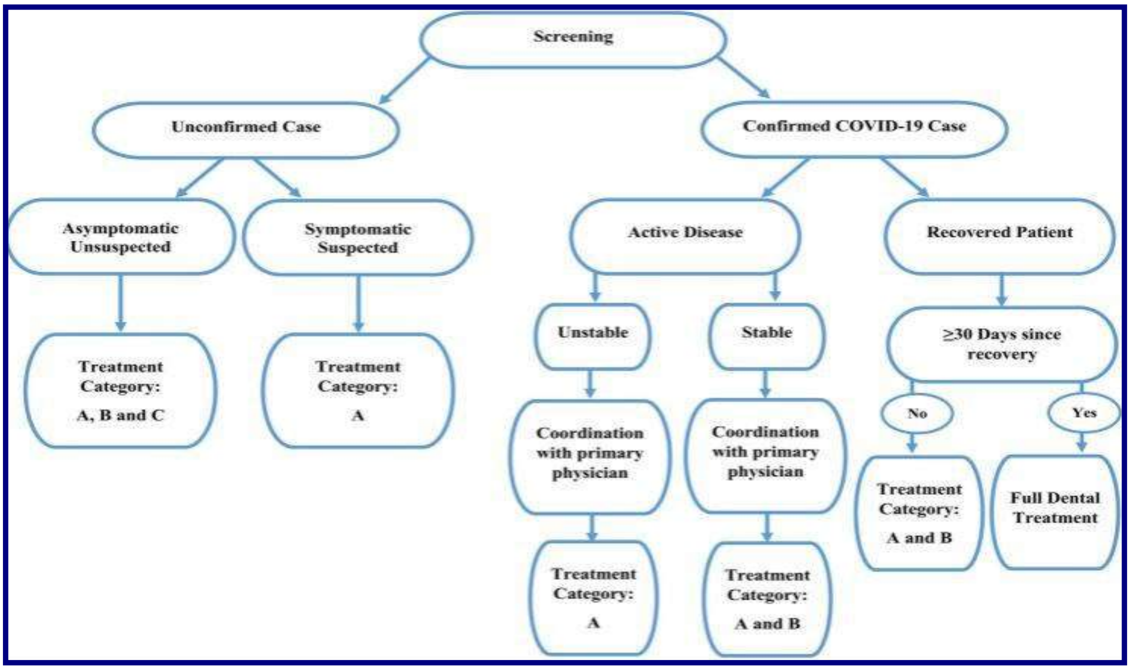


Figure 4. Flowchart showing the dental patients screening and categorization method during the COVID-19 pandemic as well as the categorization method of the affected patients after the pandemic [21].

Figure 5. Personal protective equipment.

Figure 6. N-99 Face mask.

Table 3. A guidance table showing the categories of dental treatments and the variety of treatments that can be provided for the patient during the COVID-19 pandemic (*Usually managed by oral and maxillofacial surgeons. **Pain assessment is carried out using the Universal Pain Assessment Tool (UPA)) [18].

A	B	C	D	E
Emergency.	Urgent conditions that can be managed with minimally invasive procedures and without aerosol generation.	Urgent conditions that need to be managed with invasive and/or aerosol generating procedures.	Non urgent	elective
Unstable maxillofacial fractures that can compromise patients airway.	Severe dental pain from pulpal inflammation that requires tooth extraction.	Severe dental pain from pulpal inflammation that need to be managed with aerosol generating procedures	Removable denture adjustments and repair.	Initial or periodic oral examinations and recall visits.
Diffuse bacterial soft tissue infection with intraoral/extraoral swelling that can compromise patients airway.	Severe dental pain (7≤) from fractured vital tooth that can be managed without aerosol generation**	Severe dental pain (7≤) from fractured vital tooth that need to be managed with aerosol generating procedures**	Asymptomatic fractured or defective restoration.	Aesthetic dental procedures.
Uncontrolled postoperative bleeding.	Dental trauma with avulsion/luxation that can be minimally managed without aerosol generation.	Dental trauma with avulsion/luxation that need invasive/Aerosol Generating Procedures.	Asymptomatic fractured or defective fixed prosthesis.	Restorative treatment of asymptomatic teeth.
	Surgical postoperative osteitis or dry socket that can be managed without aerosol generation.*	Deboned fixed prosthesis cleaning and temporary cementation.	Asymptomatic fractured or defective orthodontic appliance.	Extraction of asymptomatic teeth.
	Pericoronitis or third molar pain that can be managed without aerosol generation.	Removable dentures adjustments for radiation/oncology patients.	Chronic periodontal disease.	Orthodontic procedures other than those in category B/C.
	Stable maxillofacial fractures that requires no intervention.*	Fractured or defective fixed prosthesis causing soft tissue injury.		Routine dental cleaning and preventive therapies.
	Localised dental/ periodontal abscess that can be managed without aerosol generation.	Acute periodontal disease.		Replacement of missing tooth/ teeth with fixed or removable prosthesis.
	Fractured or defective fixed orthodontic appliance causing soft tissue laceration.			Dental implant surgery.

cautiously assess suitable PPE's availability to minimise virus transmission risk (Figure 5).

6.2 Dental Health Care Personnel Considerations

- Dentists will consult with all workers to present the protocols and guidance for COVID-19.
- Strict adherence to hand hygiene, including: prior to and during patient contact; after contact with contaminated surfaces or equipment; and after PPE has been removed.
- Ensure that the dental health care staff has received their seasonal flu vaccine.
- ***Regular Staff Health Screening***: Take the temperature of the staff before starting the workday. When over 100.4 degrees, workers are sent home or referred to a testing facility. Staff respond to regular questionnaire answers. Refer to a testing centre if you answer "yes" to any questions [19].

6.3 COVID-19 questionnaire

a. Do you have any of the following signs of respiratory problems? Fever, Sore Throat, Cough, Breathing Shortage?
b. Have you lost your sense of smell or taste recently?
c. Do you have any gastro-intestinal symptoms? Diarrhoea? Nausea?
d. 4. Also if you do not have any of the above symptoms at the moment, have you felt any of those symptoms in the last 14 days?
e. Have you been in touch with anyone over the last 14 days who have tested positive for COVID-19?
f. Have you travelled outside the country by air or cruise ship in the past 14 days?
g. Have you travelled within the country by air, bus, or train within the past 14 days?

If DHCP is sick, tests positive for COVID-19, or is caring for an individual that tested positive for COVID-19, the DHCP should not report to work [20].

6.4 Patient pre-appointment screenings

- Screen all patients before scheduling. Advise patients to monitor their home temperature. If it's below 100.4 degrees, then it's fine.
- Absolute registration of patients via telephone or secure email before arriving at the office.
- Administer COVID-19 questionnaire:
- Positive responses to COVID-19 questionnaire. Refer the patient to the primary health care provider. Do not schedule the patient for dental treatment [21].
- If the patient reports no symptoms, no possible contact with COVID-19 infected person, no suspicious travel, and no fever, schedule the patient for a dental appointment.
- To minimize potential contact with other patients in the waiting room, schedule separate appointments where possible [19].

6.5 Reminders to patients

- Recall patients to restrict the number of companions.
- Depending on office size, companions may need to remain in their vehicles or outside the dental office [22].
- Patient face masks-encourage patients to wear a face mask/covering as they enter and leave the exercise.
- Provide patients with guidelines by (i) keeping six feet as far as possible from all other individuals, (ii) hand hygiene, and (iii) respiratory and cough etiquette [23].

6.6 Clinical setting

6.6.1 In-Office Patient Registration Procedures

- Have hand sanitizer available for use (ideally 60% or better).
- Consider using automatic opening trash cans.
- Check patient's temperature (with a thermometer (where possible a touchless forehead scan) [21].
- Reappoint and refer if the patient's temperature rises above the threshold of 100.4 F to their primary care physician.
- Complete Patient's Screening Form. Positive answers to all of these questions, consider referring to their primary care doctor or emergency care at this time or request further information on their primary care doctor or emergency care.
- Consider pre-treatment registration remotely, to minimize in-office contact with staff.
- Do not carry the paper records of the patient into the operative [24].

6.6.2 Reception Area Preparation Strategies

Get your dental office ready for COVID-19. Via this checklist, secure the patients and employees. Emphasize hand hygiene and cough etiquette for everyone.

- Prepare the building or office entrance: provide hand sanitation before entering the facility with a warning to individuals to use it before entering into office.
- Consider providing the patient with a mask to be worn in the office, except for the dental treatment [24].
- Providing waiting areas, toilets and tissue treatment rooms for patients, alcohol-based hand cleanser, sink cleaner, garbage cans.
- Place chairs 6 feet apart, when possible.
- Delete toys, materials for reading, remote controls, or other general items.
- Wipe away all touchable surfaces with an authorised surface cleaner on a daily schedule.
- For example, tables, chair arms, doorknobs, light switches, hangers, and any other objects with which individuals may have direct contact. Using products which meet the EPA requirements for use against SARS-CoV to disinfect.
- Recall that patients limit their number of companions.
- Companions may need to remain in their cars or outside the dental office, depending on the office size [24].

6.6.3 Chairside Checklist

Dentists and staff may use this checklist to prepare the procedures during and after the patient's visit to the operating rooms for work.

Use the highest level of PPE available: PSA available: Physical strategies to interrupt or suppress the spread of respiratory viruses are: periodic hand washing (55%), mask-wearing (68%), gloves wearing (57%), gown wearing (77%); when taken together if the clinician uses full "reasonably readily available universal precautions including mask, gloves, gown and washes their hands before and after patient contact, they have a 0.09 odds ratio of contracting the disease (91% reduced chance) [25].

- If available, wear a mask, gloves, a gown, eye protection (i.e., goggles or disposable/reusable face shield covering the face's front and sides).
- If aerosols are predicted, use the highest available PPE level and recommend a respirator mask equal to N95 or N95.
- If there is no respirator (N95 or equivalent) available, use a surgical mask and face shield combination (Figure 6).
- After leaving the patient's room, respirators should be removed (and, if disposable, discarded).
- Reusable eye protection prior to reuse should be swept and disinfected.
- Clothing - Gowns: Suggest gowns for solitude. After utilisation, disposable gowns should be discarded in a dedicated waste container. After each use cloth isolation gowns should be laundered. Recommend changing gowns during aerosol processing procedures Scrubs: When scrubs are worn, change from regular clothes to intro scrubs at the dental office. Before you leave the dental office, change out of scrubs and back into normal clothes. Scrubs should be washed after or at the end of the day after soiling.
- Ensure strict adherence to hand hygiene by DHCP procedure, including prior to and after patient touch, after contact with polluted surfaces or equipment, after removal of PPE.
- Limit organisational paperwork to the greatest extent possible.
- Cover a keyboard machine with a transparent, versatile, disposable barrier and patient shift.
- Limit patient access to the operator only, if necessary. Offer someone who accompanies the patient a mask.
- Hold operational staff levels to the minimum required.
- Mask pre-entry (including chairside staff), as virus -containing aerosol particles may exist.
- No physical contact or handshaking.
- Wash hands and glove in the operatory.
- Review overall health background, confirm that the screening questions were asked during check-in and, if possible, review.
- Consider pre-treatment rinses to decrease bacterial and viral loads in aerosols.
- Usage of clinical judgment when offering some restoration or hygiene treatment to use the lowest aerosol-generating armamentarium. Using hand scaling instead of sonic/ultrasonic scaling where required. When possible, high-speed evacuations should be used.
- Consider restorative processes conducted under a rubber dam or similar (such as Isolite or Dry Shield).
- Usage of nitrous oxide: use of disposable nasal hood; either disposable or sterilized tubing should be used.
- Shock the waterlines of your dental unit if you return from an extended break in practice.
- Use professional judgement on mask/gown removal and replacement between patients if aerosols are not produced.
- Clean the operator with gloves, mask, face shield or goggles when wearing.
- Dispose and repair surface barriers after each patient's use.
- Clean detergent soap surfaces, accompanied by cleanser disinfection, use products that meet SARS -CoV-22 EPA requirements.
- Provide a mask for the patient and escort the patient from the office [17].

6.6.4 Post-procedure protocol:

- Consider delaying entry into a room where aerosols have been produced for as long as possible, up to three hours if possible.
- Guide patients as they exit the office to use their face coverings. Aim to prevent patients from moving close to each other and clean all surfaces that touch the patient.
- Wherever practicable, restrict the transfer of paperwork. Consider submitting credit card receipts and invoices via email or mail. Use payment card passing gloves and facilitate contactless methods of payment.
- Disinfect the areas entered by a patient or visitor, including door handles, chairs, and bathrooms.

- Limit follow up appointments. Consider resorbable sutures and tele-dentistry.
- Call patients 4-7 days after appointment to confirm that they do not have any COVID-19 symptoms with the same pre-appointment interview questionnaire.
- If you need to remind patients of potential exposure, keep a record of the patient schedule.
- Instruct the patient to contact the office within 14 days after the dental consultation if they develop COVID-19 symptoms.
- Consider protocol changes before successful and accurate mass immunity testing and vaccination with COVID-19 is accessible [21].

6.6.5 Office Considerations

- Have a transparent barrier separating front desk employees from patients, if necessary. Otherwise, when performing office duties such as accepting payments, arranging future meetings, etc., aim to maintain distance between the front desk and patients.
- Place barriers where possible to protect high-touch objects [19].
- Have hand sanitizer available for use in an automatic dispenser (ideally 60% alcohol or better).
- Disinfect the waiting area between patients, in addition to the periodic disinfection procedure.
- In addition to the standard disinfection protocol, disinfect operatory between patients [25].
- Disinfect high touch surfaces often.
- Limit the number of patient-surgical staff.
- In the light of patient needs and risk, dentists should decide on patient care using independent clinical judgement. In all care situations, some risk to DHCP and patient is inherent and differs from the PPE level used when treating patients.
- Use professional judgement to limit aerosol-generating procedures and employ the lowest aerosol-generating procedures whenever possible. Hand-scale rather than ultrasonic scale, if possible.
- Treating higher-risk patients: COVID-19 is a new disease, and little information is available on risk factors of severe illnesses. Consider separate office hours for patients at higher risk due to comorbidities or age [23].

7. Conclusion

Management of COVID-19 is an essential part of clinical practice. Most dental operatories are closed today to prevent the spread of the covid virus, causing undue apprehension among dental professionals. Dentists should have adequate knowledge in managing emergencies during this pandemic by adhering to strict protocols and reducing infection transmission to others and beyond.

Conflicts of interest: Authors declared no conflicts of interest.

Financial support: None

References

1. Mahdi SS, Ahmed Z, Allana R, Peretti A, Amenta F, Nadeem Bijle M, Seow LL, Daood U. Pivoting Dental Practice Management during the COVID-19 Pandemic-A Systematic Review. Medicina. 2020;56 (12):644. https://doi.org/10.3390/medicina56120644
2. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. The Lancet. 2020;395(10223):470-3. https://doi.org/10.1016/S0140-6736(20)30185-9
3. Coronavirus SARS-CoV-2 I COVID-19 pandemic: Information and Guidelines for Pharmacists and the Pharmacy Workforce (Internet).
4. Brahmanandam PS, Chakravarthy KK, Raju GR, Rao NS, Satyavani M, Kumar VN, Alla RK, Kadiyala KG, Vinay P, Rao C, Narsaiah EL. Feasible Solutions and Role of Nanomaterials in Combating the COVID-19 Pandemic: A Preliminary Study. Trends in Biomaterials & Artificial Organs. 2020 Jul 3;34.
5. Richman DD, Whitley RJ, Hayden FG, editors. Clinical virology. John Wiley & Sons; 2016 Dec 1. https://doi.org/10.1128/9781555819439.ch1
6. Gralinski LE, Menachery VD. Return of the coronavirus: 2019-nCoV. Viruses 12: 135. https://doi.org/10.3390/v12020135
7. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, Si HR, Zhu Y, Li B, Huang CL, Chen HD. A pneumonia outbreak associated with a new coronavirus of probable bat origin. nature. 2020;579 (7798):270-3. https://doi.org/10.1038/s41586-020-2012-7
8. Lu CW, Liu XF, Jia ZF. 2019-nCoV transmission through the ocular surface must not be ignored. Lancet (London, England). 2020;395(10224):e39. https://doi.org/10.1016/S0140-6736(20)30313-5
9. Zhang H, Kang Z, Gong H, Xu D, Wang J, Li Z, Cui X, Xiao J, Meng T, Zhou W, Liu J. The digestive system is a potential route of 2019-nCov infection: a bioinformatics analysis based on single-cell transcriptomes. BioRxiv. 2020 Jan 1. https://doi.org/10.1101/2020.01.30.927806
10. Peng X, Xu X, Li Y, Cheng L, Zhou X, Ren B.

Transmission routes of 2019-nCoV and controls in dental practice. Int J Oral Sci. 2020;12(1):1-6. https://doi.org/10.1038/s41368-020-0075-9

11. World Health Organization. Global surveillance for COVID-19 caused by human infection with COVID-19 virus: interim guidance, 20 March 2020. World Health Organization; 2020.
12. He X, Lau EH, Wu P, Deng X, Wang J, Hao X, Lau YC, Wong JY, Guan Y, Tan X, Mo X. Temporal dynamics in viral shedding and transmissibility of COVID-19. Nature medicine. 2020;26(5):672-5. https://doi.org/10.1038/s41591-020-0869-5
13. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic Transmission of SARS-CoV-2—Singapore, January 23–March 16, 2020. Morbidity and Mortality Weekly Report. 2020 Apr 10;69 (14):411. https://doi.org/10.15585/mmwr.mm6914e1
14. Cascella M, Rajnik M, Cuomo A, Dulebohn SC, Di Napoli R. Features, evaluation and treatment coronavirus (COVID-19). InStatpearls [internet] 2020 Mar 8. StatPearls Publishing.
15. Coulthard P. Dentistry and coronavirus (COVID-19)-moral decision-making. Brit Dent J. 2020;228(7):503 -5. https://doi.org/10.1038/s41415-020-1482-1
16. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine. J Dent Res. 2020;99(5):481 -7. https://doi.org/10.1177/0022034520914246
17. Alharbi A, Alharbi S, Alqaidi S. Guidelines for dental care provision during the COVID-19 pandemic. Saud Dent J. 2020;32(4):181-6. https://doi.org/10.1016/j.sdentj.2020.04.001
18. Kohn WG, Collins AS, Cleveland JL, Harte JA, Eklund KJ, Malvitz DM. Guidelines for infection control in dental health-care settings-2003.
19. American dental association: interim mask and face shield guidelines
20. American Dental Association. ADA interim guidance for minimizing risk of COVID-19 transmission.
21. CDC: steps healthcare facilities can take now to prepare for COVID -19.
22. CDC: interim clinical guidance for management of patients with confirmed coronavirus disease (COVID -19).
23. CDC: interim infection prevention control guidance for dental settings during COVID-19 response.
24. Jefferson T, et al: Physical interventions to interrupt or reduce the spread of respiratory viruses: systematic review. BMJ 2008;336(7635): 77-80. https://doi.org/10.1136/bmj.39393.510347.BE
25. CDC: Interim Infection Prevention and Control Guidance for Dental Settings During the COVID-19 Response EPA Disinfectants List N: Disinfectants for Use Against SARS-CoV-2.

Case Report International Journal of Dental Materials 2021; 3(1) ISSN:2582-2209

Fabrication of feeding plate to an infant with Pierre-Robin syndrome: a case report

Bhargavi Challagondla[1], Papala Sesha Reddy[2,*], Soundarya Kurakalva[1]

[1]Postgraduate Student, [2]Assistant Professor, Department of Prosthodontics, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.

I N F O R M A T I O N

Article History

Received *14th December 2020*

Accepted *26th January 2021*

Available online
22nd February 2021

K E Y W O R D S

Cleft-lip

Cleft Palate

Feeding plate

Pierre-Robin Syndrome

A B S T R A C T

Cleft lip and palate is a congenital deformity associated with maxillary sagittal and transverse discrepancies. Feeding is an immediate concern in children born with a cleft as it delays their normal growth. A feeding plate is essential for proper nutrition, and it has a role in craniofacial development and decreases the incidence of otitis media and nasopharyngeal infections. This case report describes a single visit technique for fabrication of feeding prosthesis for a 5- day old newborn infant with cleft lip and palate. The prosthesis helps in reducing the flow of food into the nasopharynx, thus decreasing the incidence of Otis media and oro-nasopharyngeal infections.

1. Introduction

Cleft lip and palate (CLP) is the most common congenital facial anomaly. According to epidemiologic studies, its incidence varies but is usually between 1 and 1.82 for every 1000 births [1,2]. Cleft lip and palate is a congenital deformity associated with maxillary sagittal and transverse discrepancies [1,3,4]. In addition to skeletal discrepancies, this deformity is often accompanied by dental abnormalities, such as hypodontia, hyperdontia, and transpositions [1,5,6]. Cleft lip and palate may or may not be associated with various syndromes such as Pierre-Robin syndrome, Stickler's syndrome, Di George syndrome, Treacher Collins malformation, trisomy 13 and 18, Apert's syndrome, and Waardenburg's syndrome [7,8].

Cleft palate is associated with difficulty in sucking, nasal regurgitation while feeding, deficiency of facial growth, dental and aesthetic problems, velopharyngeal inadequacy resulting in speech and hearing impairment and psychological problems [9]. Among all the problems, feeding is an immediate concern in children born with a cleft. Difficulty in feeding in those infants with a cleft may result in growth abnormalities. This can also be a significant concern for infants who will be undergoing surgery to correct their cleft. Cleft lip or Cleft palate can be managed by reconstructive surgery performed in the first few months after birth for Cleft lip and before 18 months for Cleft palate. Therefore, a feeding plate (FP) was recommended to the patient to overcome the problems of feeding. FP acts as a rigid platform against which the child can press the nipple to extract the milk [7,10,11]. A feeding plate is important for proper nutrition, and it has a role in craniofacial growth and decreases the incidence of otitis media and nasopharyngeal infections [12-14].

Correspondence: *Corresponding author Email Address: *drpseshareddy@gmail.com*

How to cite this article: Challagondla B, Sesha Reddy P, Kurakalva S. Fabrication of feeding plate to an infant with Pierre-Robin syndrome: a case report. Int J Dent Mater 2021;3(1): 33-36.
DOI: http://dx.doi.org/10.37983/IJDM.2021.3105

2. Case Report

The patient was five days old female patient with a cleft palate who weighed 2.5 kg. The baby was referred by the Department of Paediatrics to the Department of Prosthodontics and Crown &Bridge, Government Dental College and Hospital, Kadapa, for the fabrication of a feeding plate. On examination, it was found that the child is having Pierre-Robin syndrome with underdeveloped ears and retrognathism and cleft palate (Figure 1). After a complete examination of the patient, it was decided to fabricate a feeding plate for the patient to reduce the feeding problem.

3. Procedure

The preliminary impression of the maxillary arch was made with vinyl polysiloxane putty material (Adsil Putty, prime ltd) with the help of an impression tray made of self-cure acrylic resin (DPI cold cure acrylic) to hold the impression material (Figure 2). The infant was held upright by the mother to prevent the aspiration of impression material. The putty addition silicone was adapted until the impression material adequately covered the anatomy of the upper gum pads. Once the impression material was set, the putty tray was removed, and the mouth was examined for residual impression material. Beading was done around the impression with plaster of Paris and boxing was done with boxing wax. The impression was then poured with Type IV dental stone to obtain an accurate cast (Figure 3). All the undercuts were blocked out with plaster of Paris. The feeding plate was made up of an adapted vacuum-formed thermoplastic sheet.

The suturing thread was attached to the feeding appliance because it prevents swallowing and easy retrieval of the appliance (Figure 4). The appliance was placed in the child's oral cavity (Figure 5), and the final adjustment was made until the child feels comfortable with the appliance (Figure 6). Instructions were given to the parents to keep the plate in place during feeding and take out. Also, instructed to clean the appliance after feeding. Initially, it may take longer to feed the child with the plate, and even it is uncomfortable for the child, gradually it should be adjusted.

4. Discussion

Cleft lip & palate runs in families and predilection for some races have also been documented. Cleft lip and palate is present approximately 1 in 750 live births, 0.133%. The male child has two times more predilection for Cleft lip & palate compared to female [15-17].

According to literature, there are various ways by which the problem of feeding may be tackled, i.e. (a) Specially designed nipples with wide openings that can increase the ejection of milk with reduced effort. (b) Orogastric or nasogastric tubes may be used but for a limited length of time. (c) Presurgical infant maxillary Orthopedics (PIMO) may prove beneficial to the surgeon if a better alignment and closer approximation of the cleft segments is achieved before the actual surgical repair. (d) Surgery may close the communication, but it may not prove beneficial in all cases, especially when the separation between the cleft segments is large (e) palatal obturator that is a definite help to the feeding of an infant [15,17]. Obturator can also help in speech and language development, but unfortunately, little work has been done in this area [15].

Treatment of Cleft lip & palate is a teamwork of the pediatrician, plastic surgeon, pedodontist, and prosthodontist. Cleft lip and Cleft palate are successfully treated by plastic and reconstructive surgery. However, till the surgery, to overcome the problems associated with the feeding and to restore the weight required for surgery, a temporary appliance known as Feeding plate is fabricated by the pedodontist or prosthodontist to break the vicious cycle of low weight due to which the patient becomes unfit for surgery [7].

Making an impression is the first and foremost challenging clinical step in Cleft palate infants because of lack of cooperation on behalf of the patient. The oral cavity is very small to be adequate for commercially available impression trays, with a risk of swallowing and aspiration of impression material or even being lodged in the undercuts of the defect [12,18,19]. Hence, it is crucial to take care of the proper positioning of the infant, a tray used and the impression material in order to maintain airway patency during impression making [12]. The feeding plate was inserted on the same day considering high anxiety of the baby's mother regarding the decreased weight of the infant relative to his age. The average weight gain of the infant indicated the proper function of the feeding plate [12].

Figure 1. Baby having cleft palate.
Figures 2-6. Fabrication of feeding plate, where 2. impression of maxillary arch with cleft using custom tray and putty, 3. Maxillary master cast with cleft plate, 4. Feeding plate fabricated with thermoplastic sheet , 5. Feeding plate insertion, 6. Happily sucking baby, and 7. Follow-up after 2 months.

5. Conclusion

The Feeding plate overcomes the hindrances that occur during the normal growth and development of a cleft patient and should be advised as early as possible after birth. It acts as an essential tool for feeding, oral-facial development, palatal shelves development, prevention of tongue distortion, nasal regurgitation and nasal septum irritation, and avoiding ear infections. Also, it prevents the expansion of the anterior part of the maxilla, which helps the surgeon provide proper reconstructive treatment.

Conflict of interest: Authors declare no conflicts of interest.
Financial Support: None

References

1. Ambarkova V, Djipunova B, Batra M, Trajkova S. Oral Rehabilitation of patient with Cleft Lip and Palate - a case report. J Dent Probl Solut. 2017;4(4):061-065. https://doi.org/10.17352/2394-8418.000051
2. Derijcke A, Eerens A, Carels C. The incidence of oral clefts: a review. Br J Oral Maxillofacial Surg. 1996;34:488–494.

https://doi.org/10.1016/S0266-4356(96)90242-9

3. Baek SH, Moon HS, Yang WS. Cleft type and Angle's classification of malocclusion in Korean cleft patients. Eur J Orthod. 2002; 24: 647–653. https://doi.org/10.1093/ejo/24.6.647
4. Vettore MV, Sousa Campos AE. Malocclusion characteristics of patients with cleft lip and/or palate. Eur J Orthod. 2011; 33: 311–317. https://doi.org/10.1093/ejo/cjq078
5. Tereza GP, Carrara CF, Costa B. Tooth abnormalities of number and position in the permanent dentition of patients with complete bilateral cleft lip and palate. Cleft Palate Craniofac J. 2010; 47: 247–252. https://doi.org/10.1597/08-268.1
6. Akcam MO, Evirgen S, Uslu O, Memikoglu UT. Dental anomalies in individuals with cleft lip and/or palate. Eur J Orthod. 2011; 32: 207–213. https://doi.org/10.1093/ejo/cjp156
7. Tulsi G, Surendra Kumar B. Fabrication of Feeding Plate in Cleft Palate Patient: A Case Report. Dent J Adv Stud 2019;7:35-37. https://doi.org/10.1055/s-0039-1684106
8. Chandna P, Adlakha VK, Singh N. Feeding obturator appliance for an infant with cleft lip and palate. J Indian Soc PedodPrev Dent 2011;29(1):71–73. https://doi.org/10.4103/0970-4388.79950
9. Rathee M, Hooda A, Tamarkar A, Yadav S. Role of feeding plate in cleft palate: case report and review of literature. Internet J Otorhinolaryngol. 2010;12:1. https://doi.org/10.5580/13a0
10. Oxford Concise Medical Dictionary. 8th ed. Oxford University Press:2010:208.
11. Kogo M, Okada G, Ishii S, Shikata M, Iida S, Matsuya T. Breast feeding for cleft lip and palate patients, using the Hotz-type plate. Cleft Palate Craniofac J. 1997;34(4):351–353. https://doi.org/10.1597/1545-1569_1997_034_0350_bffcla_2.3.co_2
12. Amro M, Abdullah K. A single – visit feeding plate for a 3- month- old infant with cleft palate: A case report. J Dent Res Dent Prospect. 2017;11(4):253-256.
13. Duarte, G.A., R.B. Ramos, and M.C. Cardoso, Feeding methods for children with cleft lip and/or palate: a systematic review. Braz J Otorhinolaryngol, 2016; 82 (5):602-9. https://doi.org/10.1016/j.bjorl.2015.10.020
14. Kumari A. Fabrication of feeding plate prosthesis for a six days old neonate: a case report. Int J Dent Mater. 2019;1(3):89-92. https://doi.org/10.37983/IJDM.2019.1304
15. Rajesh B, Pathak A,Baldev B. Rehabilitation of a One -day-Old Neonate with Cleft Lipp and Palate using Palatal Obturator: A Case Report. Inter J Clin Pedia Dent. 2012;5(2):145-147. https://doi.org/10.5005/jp-journals-10005-1154
16. Sesgin MJ, Stark RB. The incidence of congenital defects. Plast Reconstr Surg Transplant Bull. 1961; 27: 261-267. https://doi.org/10.1097/00006534-196103000-00003
17. Green JC, Vermillion JR, Hay S, Gibbens SF, KerschbaumS. Epidemiologic study of cleft lip and palate in four states. J Am Dent Assoc. 1964;68:386-404. https://doi.org/10.14219/jada.archive.1964.0079
18. Jones SD, Drake DJ. Case series of undetected intranasal impression material in patients with clefts. Br J Oral Maxillofac Surg, 2013; 51(3):34-6. https://doi.org/10.1016/j.bjoms.2011.11.015
19. Reichert F, Amrhein P, Uhlemann F. Unnoticed aspiration of palate plate impression material in a neonate: Diagnosis, therapy, outcome. Pediatr Pulmonol, 2017; 52(10):E58-60. https://doi.org/10.1002/ppul.23710

International Journal of Dental Materials

Volume 3 Number 1 January-February 2020

Contents