
Comparative Evaluation On Number Of Increments Of Composites Used For Restoring Mesio - Occlusal Cavities Of Maxillary And Mandibular Molars - A Retrospective Study

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Abstract: Dental composites are generally composed of matrix monomers such as Bis-GMA and UDMA and silica is commonly used as filler. Modifying the composition and size of filler particles, have improved wear resistance of composites. With advances in adhesives and bonding strategies, the interface of tooth-restoration is improvised but still microleakage due to polymerization shrinkage stresses is a major drawback of composite resin restorations. Incremental layering technique of placing composite restorations greatly reduced the shrinkage stresses. This study was done to evaluate the number of increments of composite used for restoring mesio-occlusal cavities of maxillary and mandibular molars in the South Indian population. A total of 142 case sheets of patients who underwent class II mesio-occlusal composite restorations in maxillary and mandibular molars were reviewed, analyzed and comparatively evaluated. The statistical analysis was done using SPSS software (Version 23). In our study, the patients selected were in the age group of 18- 65 years. Class 2 composite restorations were mostly done in the age group of 31- 40 years followed by 18-30 years respectively. In the selected cases, 74 (52.1%) were male and 68 (47.8%) were female patients. Maxillary right first and second molars were the most commonly treated teeth. Out of 142 teeth, 39 teeth (27.4%) used 1 increment, 81 teeth (57%) used 2 increments and 22 teeth (15.4 %) used 3 increments of composite for restoration of class II cavities. Two increments of composites were used in most cases of mesio-occlusal cavities of all posterior teeth. The association between age, gender and number of composite increments did not have any statistically significant difference in maxillary and mandibular class II cavities ($p > 0.05$). From this study we observed that all the teeth were restored in a conservative approach.

Keywords: Class 2 Cavity, Class 2 Composites, Composite Restorations, Increments, Mesio-Occlusal Cavity.

INTRODUCTION

Dental polymer composites have three major components such as inorganic fillers, an organic polymer matrix and a coupling agent (Braga, Ballester and Ferracane, 2005). Bis-GMA and UDMA are commonly employed monomers and silica acts as filler (Atai, Watts and Atai, 2005). Dilutant co-monomers such as TEGDMA improve handling properties. Glass/ceramic fillers would improve optical properties and wear resistance (Ferracane, Bertassoni and Pfeifer, 2017). Fillers are added to achieve increased strength, reduced polymerization shrinkage and heat generation. The monomer influences the viscosity, reactivity, polymerization shrinkage, mechanical properties, water uptake and swelling behaviour of composites (Papadogiannis *et al.*, 2011), (Kumar and Ashok kumar, 2017).

Sufficient polymerization and depth of cure are parameters directly influencing the longevity of the restoration (Miletic, 2017). Insufficient monomer conversion would lead to initiator leaching, less biocompatibility, reduced mechanical and wear properties and colour instability (Schneider and Moraes, 2018). High monomer conversion, on the other hand, leads to high polymerization shrinkage and heat generation (Marovic *et al.*, 2013).

Factors responsible for polymerization shrinkage include restorative procedure, light intensity, cavity design, polymerization characteristics, type of monomer used and filler loading (Santhosh, Bashetty and Nadig, 2008).

Clinical signs associated with polymerization shrinkage stress include inadequate adaptation at tooth/ restoration interface, micro-cracking, post-operative sensitivity, microleakage and secondary caries (Drummond, 2008).

Restorative composite formulations such as silorane-based composites minimize polymerization shrinkage by photo cationic ring opening (Yoshida *et al.*, 2008),(Weinmann, Thalacker and Guggenberger, 2005). It is a chemical combination of siloxane and oxirane and less shrinkage than methacrylates (Ilie *et al.*, 2007). Modulating filler content and elastic properties also help in reducing the polymerization shrinkage (Masouras, Silikas and Watts, 2008).

The main elements to reduce shrinkage stress include, use of a small volume of material, a lower cavity configuration factor and minimal contact with opposing cavity walls during polymerization. Incremental laying technique would help by reduced polymerization material volume and each successive layer compensates for previous increment (Rudrapati *et al.*, 2017). Our team has rich experience in research and we have collaborated with numerous authors over various topics in the past decade (Deogade, Gupta and Ariga, 2018; Ezhilarasan, 2018; Ezhilarasan, Sokal and Najimi, 2018; Jeevanandan and Govindaraju, 2018; J *et al.*, 2018; Menon *et al.*, 2018; Prabakar *et al.*, 2018; Rajeshkumar *et al.*, 2018, 2019; Vishnu Prasad *et al.*, 2018; Wahab *et al.*, 2018; Dua *et al.*, 2019; Duraisamy *et al.*, 2019; Ezhilarasan, Apoorva and Ashok Vardhan, 2019; Gheena and Ezhilarasan, 2019; Malli Sureshbabu *et al.*, 2019; Mehta *et al.*, 2019; Panchal, Jeevanandan and Subramanian, 2019; Rajendran *et al.*, 2019; Ramakrishnan, Dhanalakshmi and Subramanian, 2019; Sharma *et al.*, 2019; Varghese, Ramesh and Veeraiyan, 2019; Gomathi *et al.*, 2020; Samuel, Acharya and Rao, 2020)

The objective of this study was to evaluate the number of increments of composites used for restoring mesio-occlusal cavities of maxillary and mandibular in South Indian population.

MATERIALS AND METHODS

This comparative retrospective study was conducted at Saveetha Dental College in 2020. Case sheets were analyzed from June 2019 to April 2020. The patient case sheets were obtained from the database which chronologically has all the records of patient's details, the treatment done and information regarding their follow up.

A total of 142 case sheets of patients undergoing Class II Mesio-Occlusal (MO) composite restoration in maxillary and mandibular molars were reviewed, evaluated and analysed. The age, gender, tooth number and number of increments of composite used to restore the MO cavities were checked and verified by the photographs to avoid sampling bias.

The patients included in the study were in the age group of 18-65 years of age. Incomplete data were verified from concurred patient case sheets/ department. Gross incompletely filled case sheets were excluded as it affects the study. The data were tabulated in excel sheets.

STATISTICAL ANALYSIS

Statistical analysis was done using SPSS software. The independent variables assigned as age, gender, number of increments of composites and dependent variables were right and left, maxillary and mandibular molars treated with class II MO composite restoration. Chi square test was used to check the association between tooth and the number of increments used for restoration. The analysis was performed using SPSS software (SPSS Version 23.0, SPSS, Chicago, IL, USA). The result was considered to be statistically significant when p value was less than 0.05.

RESULTS AND DISCUSSION

A total of 142 case sheets were evaluated. In our study, the patients selected were in the age group of 18- 65 years. The number of Class 2 composite restorations were done mostly in the age group of 31- 40 years followed by 18-30 years groups respectively (Fig 1).

Two increments were mostly used in restoration of class II composite restoration amongst gender. However, Chi square showed there was no significant association between gender and number of composites turns used for restoring class II mesio occlusal cavities of maxillary and mandibular molars ($p > 0.05$) (Table 1), (Fig 2). Maxillary right first and second molars were the most commonly treated teeth. Two increments of composites were used in most cases of mesio-occlusal cavities in upper and lower molars, Chi square showed the association between teeth and number of composite increments did not have a statistically significant difference in maxillary and mandibular class II cavities ($p > 0.05$) (Table 2),(Fig 3).

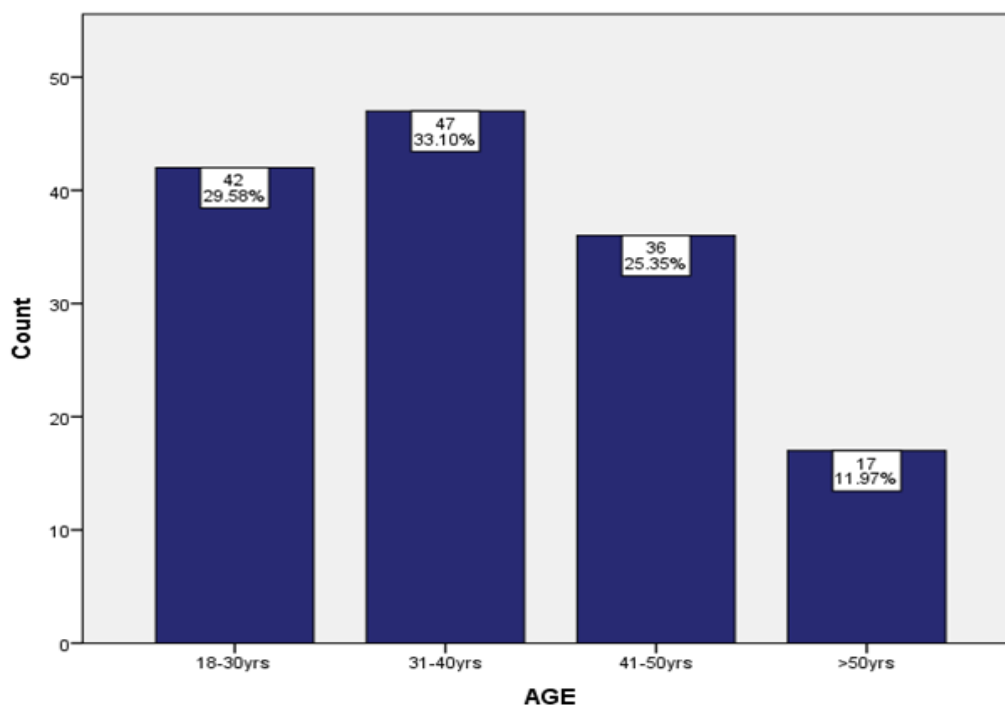


Fig.1: Bar chart depicting the frequency distribution of age groups in patients with class II MO composite restorations. X axis represents the age group. Y axis represents frequency of Class II MO composite restorations. The highest frequency of patients treated for class II MO composite restorations were found in the age group of 31-40 years, followed by 18-30 years and 41-50 years.

Table 1

Gender	Number of Increments			p value
	1	2	3	
Male	18	42	14	.422
Female	21	39	8	
Total	39	81	22	

Table 1 shows the association between gender and number composite turns used for restoring mesio occlusal class II composite restoration, Chi square test, $p = 0.422$. ($p > 0.05$) - statistically not significant.

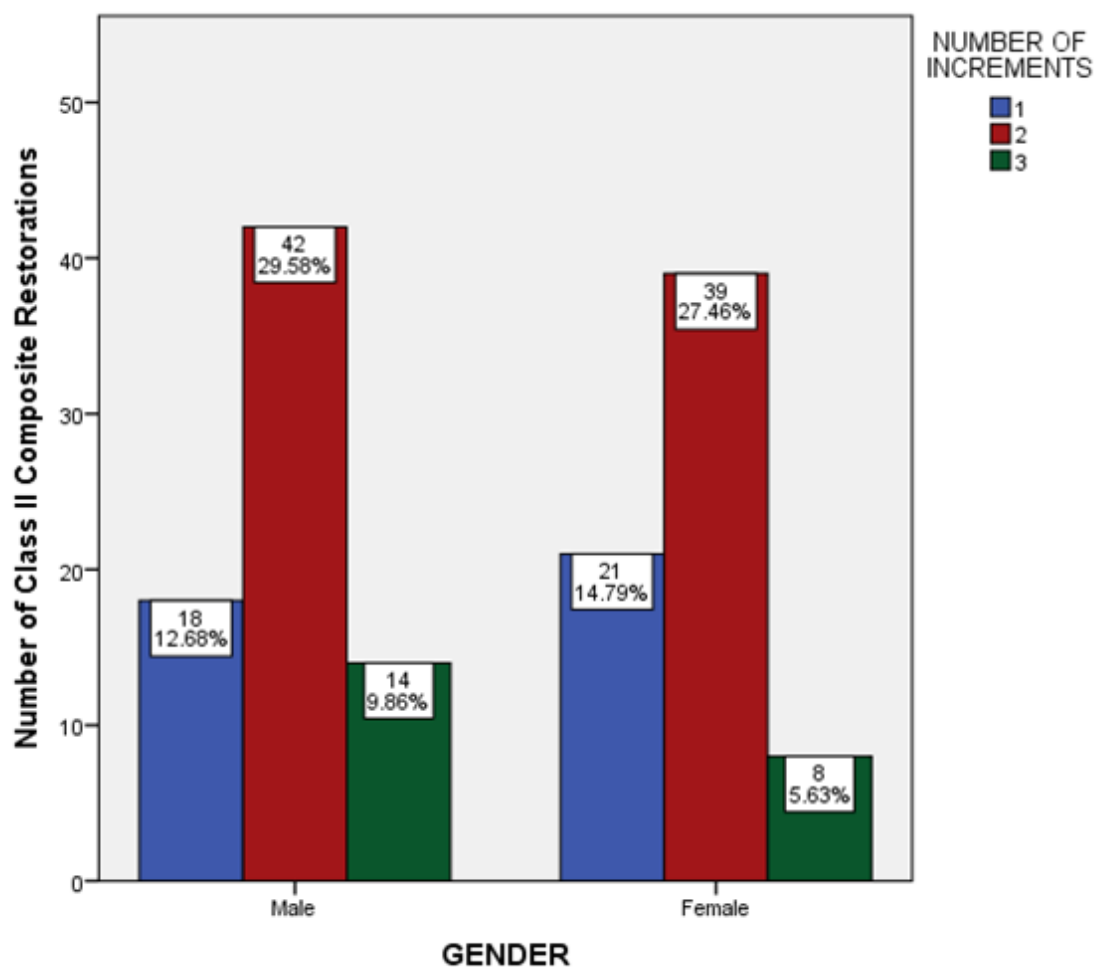


Fig.2:Bar chart indicating the association between gender of patient and number of composite turns used for restoring mesio occlusal cavities in maxillary and mandibular molars. X axis represents the gender,Y axis represents the number of class II composite restoration done. In both genders, 2 composite increments (red color) was most commonly used followed by 1 composite increments (blue color) and then 3 composite increments (green color), however, Chi square test,p = .422, showed no statistical significant difference (p >0.05)

Table 2

No. of Composite Increments		1	2	3	p value
Tooth number	Maxillary right first and second molars	26	41	16	.215
	Maxillary left first and second molars	4	7	3	
	Mandibular right first and second molars	6	21	1	
	Mandibular left first and second molars	3	12	2	

Table 2 represents association between Tooth number and Number of Composite Increments used for restoring mesio occlusal class II composite restoration, chi square showed, $p=0.215$ statistically not significant ($p>0.05$).

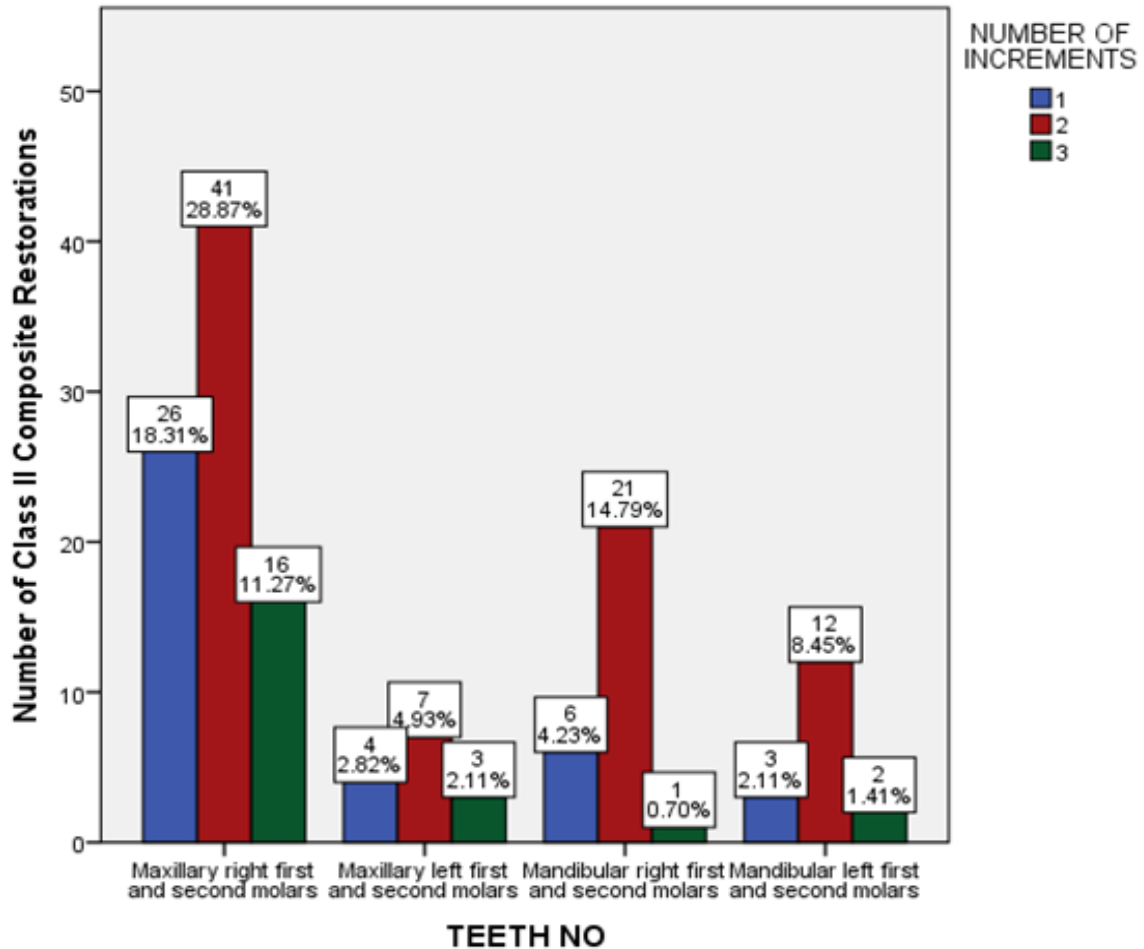


Fig.3:Bar chart depicting the number of composites increments used for restoring individual right and left maxillary and mandibular molars. X axis represents the teeth, Y axis represents the number of class II composite restoration done.In all first and second maxillary and mandibular molars, 2 composite increments (red color) was most commonly used followed by 1 composite increments (blue color) and then 3 composite increments (green color),Chi square test, $p=0.215$, showed no statistical significance ($p >0.05$)

Dental caries is commonly seen in all age groups and the rate of caries formation and progression varies with every individual. Proximal caries may often go unnoticed and lately diagnosed when the patient reports with sensitivity or pain. With the advancements in caries diagnostic techniques and the radiographs, the caries can be detected at the earliest and appropriate treatment and follow up can be started. Treating the caries at the earliest, helps to avoid painful root canal treatment, which involves meticulous cleaning and shaping of the root canal system (Ramamoorthi, Nivedhitha and Divyanand, 2015). The Cleaning and shaping of root canals should be judicious to maintain as much cervical dentin as possible (Ramanathan and Solete, 2015),(Teja and Ramesh, 2019). The remaining dentin thickness mainly decides the longevity of the tooth as well as the restoration. Various irrigants have been studied for their interactions, antimicrobial properties and substantivity(Siddique *et al.*, 2019),(Noor, S Syed Shihaab and Pradeep, 2016). The inflammatory pulp should be removed completely to achieve success in root canal treatment (Ramesh, Teja and Priya, 2018). In case of apical periodontitis, the root canal should be packed with intracanal medication, before proceeding with obturation (Manohar and Sharma, 2018).

The traumatic injuries affecting teeth include fractures, luxation, avulsion and subluxation (Jose, P. and Subbaiyan, 2020),(R, Rajakeerthi and Ms, 2019). Following trauma, the teeth might even be cracked, and more prone to decay. Care should be taken to check the vitality of pulp at regular recall visits before any invasive

procedures. The traumatised teeth undergo necrosis and canals undergo calcification in many cases (Janani, Palanivelu and Sandhya, 2020),(Kumar and Delphine Priscilla Antony, 2018).

Advances in Bonding systems and strategies have led to resin composites that offer excellent esthetics, good polishability and increased wear resistance. Due to polymerization shrinkage stresses occurring as a result of volumetric contraction, there is a marginal gap leading to microleakage, staining, secondary caries and sensitivity (Rudrapati *et al.*, 2017).

According to Nadig *et al.*, the microleakage was less in incremental techniques when compared to bulk fill technique. Among all techniques, split horizontal incremental technique showed less microleakage followed by centripetal and oblique placement technique at occlusal margin of Class II restoration (Bugalia *et al.*, 2011). Khier and Hassan studied the efficacy of 3 placement techniques in marginal sealing of Class V composite restorations extending onto root and concluded that oblique and occlusal gingival incremental techniques exhibited high degree of microleakage at occlusal and gingival margins (Khier and Hassan, 2011).

There were studies comparing different incremental placement techniques. This is the first study to evaluate the number of increments used to restore mesio-occlusal cavities of maxillary and mandibular molars and the association of age and gender with class II (MO) composite restorations. In a critical review by Arvind Shenoy, he studied that composites were viable alternatives to amalgam for posterior restorations but are more technique sensitive and longevity and mechanical strength were less than amalgam (Shenoy, 2008).

Bicalho *et al.*, studied shrinkage and shrinkage stresses using incremental filling techniques and concluded that by using low shrinkage composites applied in medium increment sizes of approximately 2mm, provided best balance compared to bulk or 1 mm increment placement (Bicalho *et al.*, 2014). Misilli *et al.*, did a study to evaluate marginal microleakage in composite restorations with different placement techniques such as bulk, oblique, centripetal, split horizontal. All techniques showed similar results when margins were located on enamel. Incremental techniques showed lesser microleakage especially at occlusal margin of restoration compared to bulk placement (Misilli and Yılmaz, 2018).

Sarfi *et al.*, proposed that siloranes exhibit significantly less microleakage as compared to nanofill composites irrespective of layering technique used. The limitation of the study includes a very small sample size and population which cannot be generalized to a larger one. Early caries detection leads to minimal intervention techniques (Sarfi, Bali and Grewal, 2017),(Ravinthar and Jayalakshmi, 2018). White spot lesions can be treated by remineralising agents and resin infiltration techniques (Rajendran *et al.*, 2019),(Nasim and Nandakumar, 2018). Apart from composites. Glass ionomer cements and its resin modified form are also used as a base in case of deep proximal restorations (Nasim *et al.*, 2018). Our institution is passionate about high quality evidence based research and has excelled in various fields ((Pc, Marimuthu and Devadoss, 2018; Ramesh *et al.*, 2018; Ezhilarasan, Apoorva and Ashok Vardhan, 2019; Ramadurai *et al.*, 2019; Sridharan *et al.*, 2019; Vijayashree Priyadharsini, 2019; Mathew *et al.*, 2020)

CONCLUSION

Within the limitations of this study, there was no significant association seen between age, gender, and number of increments of composites, used for restoring mesio-occlusal cavities of maxillary and mandibular molars. Most cases used two increments of composites, that accounts for the conservative cavity preparation designs in composite resin restorations. Hence, the incremental layering technique, with increment sizes of not more than 2 mm should be used to minimize polymerization shrinkage stresses. From this study we observed that all the teeth were restored in a conservative approach.

REFERENCES

1. Atai, M., Watts, D. and Atai, Z. (2005) 'Shrinkage strain-rates of dental resin-monomer and composite systems', *Biomaterials*, pp. 5015–5020. doi: 10.1016/j.biomaterials.2005.01.022.
2. Bicalho, A. A. *et al.* (2014) 'Incremental Filling Technique and Composite Material—Part II: Shrinkage and Shrinkage Stresses', *Operative Dentistry*, pp. e83–e92. doi: 10.2341/12-442-1.
3. Braga, R., Ballester, R. and Ferracane, J. (2005) 'Factors involved in the development of polymerization shrinkage stress in resin-composites: A systematic review', *Dental Materials*, pp. 962–970. doi: 10.1016/j.dental.2005.04.018.
4. Bugalia, A. *et al.* (2011) 'Effect of Four Different Placement Techniques on Marginal Microleakage in Class II Composite Restorations: An in vitro Study', *World Journal of Dentistry*, pp. 111–116. doi: 10.5005/jp-journals-10015-1066.
5. Deogade, S., Gupta, P. and Ariga, P. (2018) 'Effect of monopoly-coating agent on the surface roughness of a tissue conditioner subjected to cleansing and disinfection: A Contact Profilometric In vitro study', *Contemporary Clinical Dentistry*, p. 122. doi: 10.4103/ccd.ccd_112_18.
6. Drummond, J. L. (2008) 'Degradation, Fatigue, and Failure of Resin Dental Composite Materials', *Journal of Dental Research*, pp. 710–719. doi: 10.1177/154405910808700802.
7. Dua, K. *et al.* (2019) 'The potential of siRNA based drug delivery in respiratory disorders: Recent advances

- and progress', *Drug development research*, 80(6), pp. 714–730.
8. Duraisamy, R. et al. (2019) 'Compatibility of Nonoriginal Abutments With Implants: Evaluation of Microgap at the Implant-Abutment Interface, With Original and Nonoriginal Abutments', *Implant dentistry*, 28(3), pp. 289–295.
 9. Ezhilarasan, D. (2018) 'Oxidative stress is bane in chronic liver diseases: Clinical and experimental perspective', *Arab journal of gastroenterology: the official publication of the Pan-Arab Association of Gastroenterology*, 19(2), pp. 56–64.
 10. Ezhilarasan, D., Apoorva, V. S. and Ashok Vardhan, N. (2019) 'Syzygium cumini extract induced reactive oxygen species-mediated apoptosis in human oral squamous carcinoma cells', *Journal of oral pathology & medicine: official publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology*, 48(2), pp. 115–121.
 11. Ezhilarasan, D., Sokal, E. and Najimi, M. (2018) 'Hepatic fibrosis: It is time to go with hepatic stellate cell-specific therapeutic targets', *Hepatobiliary & pancreatic diseases international: HBPD INT*, 17(3), pp. 192–197.
 12. Ferracane, J., Bertassoni, L. E. and Pfeifer, C. S. (2017) *Dental Biomaterials, An Issue of Dental Clinics of North America*, E-Book. Elsevier Health Sciences.
 13. Gheena, S. and Ezhilarasan, D. (2019) 'Syringic acid triggers reactive oxygen species-mediated cytotoxicity in HepG2 cells', *Human & experimental toxicology*, 38(6), pp. 694–702.
 14. Gomathi, A. C. et al. (2020) 'Anticancer activity of silver nanoparticles synthesized using aqueous fruit shell extract of Tamarindus indica on MCF-7 human breast cancer cell line', *Journal of Drug Delivery Science and Technology*, p. 101376. doi: 10.1016/j.jddst.2019.101376.
 15. Ilie, N. et al. (2007) 'Low-shrinkage Composite for Dental Application', *Dental Materials Journal*, pp. 149–155. doi: 10.4012/dmj.26.149.
 16. Janani, K., Palanivelu, A. and Sandhya, R. (2020) 'Diagnostic accuracy of dental pulse oximeter with customized sensor holder, thermal test and electric pulp test for the evaluation of pulp vitality - An in vivo study', *Brazilian Dental Science*. doi: 10.14295/bds.2020.v23i1.1805.
 17. Jeevanandan, G. and Govindaraju, L. (2018) 'Clinical comparison of Kedo-S paediatric rotary files vs manual instrumentation for root canal preparation in primary molars: a double blinded randomised clinical trial', *European Archives of Paediatric Dentistry*, pp. 273–278. doi: 10.1007/s40368-018-0356-6.
 18. Jose, J., P., A. and Subbaiyan, H. (2020) 'Different Treatment Modalities followed by Dental Practitioners for Ellis Class 2 Fracture – A Questionnaire-based Survey', *The Open Dentistry Journal*, pp. 59–65. doi: 10.2174/1874210602014010059.
 19. J, P. C. et al. (2018) 'Prevalence and measurement of anterior loop of the mandibular canal using CBCT: A cross sectional study', *Clinical implant dentistry and related research*, 20(4), pp. 531–534.
 20. Khier, S. and Hassan, K. (2011) 'Efficacy of Composite Restorative Techniques in Marginal Sealing of Extended Class V Cavities', *ISRN Dentistry*, pp. 1–5. doi: 10.5402/2011/180197.
 21. Kumar, D. and Delphine Priscilla Antony, S. (2018) 'Calcified Canal and Negotiation-A Review', *Research Journal of Pharmacy and Technology*, p. 3727. doi: 10.5958/0974-360x.2018.00683.2.
 22. Kumar, N. A. and Ashok kumar, N. (2017) 'Overview and Recent Advancements in Composite Materials', *International Journal for Research in Applied Science and Engineering Technology*, pp. 615–616. doi: 10.22214/ijraset.2017.2092.
 23. Malli Sureshbabu, N. et al. (2019) 'Concentrated Growth Factors as an Ingenious Biomaterial in Regeneration of Bony Defects after Periapical Surgery: A Report of Two Cases', *Case reports in dentistry*, 2019, p. 7046203.
 24. Manohar, M. and Sharma, S. (2018) 'A survey of the knowledge, attitude, and awareness about the principal choice of intracanal medicaments among the general dental practitioners and nonendodontic specialists', *Indian Journal of Dental Research*, p. 716. doi: 10.4103/ijdr.ijdr_716_16.
 25. Marovic, D. et al. (2013) 'Degree of conversion and microhardness of dental composite resin materials', *Journal of Molecular Structure*, pp. 299–302. doi: 10.1016/j.molstruc.2012.10.062.
 26. Masouras, K., Silikas, N. and Watts, D. C. (2008) 'Correlation of filler content and elastic properties of resin-composites', *Dental Materials*, pp. 932–939. doi: 10.1016/j.dental.2007.11.007.
 27. Mathew, M. G. et al. (2020) 'Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary ...', *Clinical oral investigations*. Available at: <https://link.springer.com/article/10.1007/s00784-020-03204-9>.
 28. Mehta, M. et al. (2019) 'Oligonucleotide therapy: An emerging focus area for drug delivery in chronic inflammatory respiratory diseases', *Chemico-biological interactions*, 308, pp. 206–215.
 29. Menon, S. et al. (2018) 'Selenium nanoparticles: A potent chemotherapeutic agent and an elucidation of its mechanism', *Colloids and Surfaces B: Biointerfaces*, pp. 280–292. doi: 10.1016/j.colsurfb.2018.06.006.
 30. Miletic, V. (2017) *Dental Composite Materials for Direct Restorations*. Springer.
 31. Misilli, U. and Yilmaz, F. (2018) 'Evaluation of marginal microleakage in composite restorations with

- different placement techniques', *International Dental Research*, pp. 70–77. doi: 10.5577/intdentres.2018.vol8.no2.4.
32. Nasim, I. et al. (2018) 'Clinical performance of resin-modified glass ionomer cement, flowable composite, and polyacid-modified resin composite in noncarious cervical lesions: One-year follow-up', *Journal of Conservative Dentistry*, p. 510. doi: 10.4103/jcd.jcd_51_18.
 33. Nasim, I. and Nandakumar, M. (2018) 'Comparative evaluation of grape seed and cranberry extracts in preventing enamel erosion: An optical emission spectrometric analysis', *Journal of Conservative Dentistry*, p. 516. doi: 10.4103/jcd.jcd_110_18.
 34. Noor, S. S. S. E., S Syed Shihaab and Pradeep (2016) 'Chlorhexidine: Its properties and effects', *Research Journal of Pharmacy and Technology*, p. 1755. doi: 10.5958/0974-360x.2016.00353.x.
 35. Panchal, V., Jeevanandan, G. and Subramanian, E. M. G. (2019) 'Comparison of post-operative pain after root canal instrumentation with hand K-files, H-files and rotary Kedo-S files in primary teeth: a randomised clinical trial', *European archives of paediatric dentistry: official journal of the European Academy of Paediatric Dentistry*, 20(5), pp. 467–472.
 36. Papadogiannis, D. et al. (2011) 'Viscoelastic properties of low-shrinking composite resins compared to packable composite resins', *Dental Materials Journal*, pp. 350–357. doi: 10.4012/dmj.2010-181.
 37. Pc, J., Marimuthu, T. and Devadoss, P. (2018) 'Prevalence and measurement of anterior loop of the mandibular canal using CBCT: A cross sectional study', *Clinical implant dentistry and related research*. Available at: <https://europepmc.org/article/med/29624863>.
 38. Prabakar, J. et al. (2018) 'Comparative Evaluation of Retention, Cariostatic Effect and Discoloration of Conventional and Hydrophilic Sealants - A Single Blinded Randomized Split Mouth Clinical Trial', *Contemporary clinical dentistry*, 9(Suppl 2), pp. S233–S239.
 39. Rajendran, R. et al. (2019) 'Comparative Evaluation of Remineralizing Potential of a Paste Containing Bioactive Glass and a Topical Cream Containing Casein Phosphopeptide-Amorphous Calcium Phosphate: An in Vitro Study', *Pesquisa Brasileira em Odontopediatria e Clínica Integrada*, pp. 1–10. doi: 10.4034/pboci.2019.191.61.
 40. Rajeshkumar, S. et al. (2018) 'Biosynthesis of zinc oxide nanoparticles using *Mangifera indica* leaves and evaluation of their antioxidant and cytotoxic properties in lung cancer (A549) cells', *Enzyme and microbial technology*, 117, pp. 91–95.
 41. Rajeshkumar, S. et al. (2019) 'Antibacterial and antioxidant potential of biosynthesized copper nanoparticles mediated through *Cissus arnotiana* plant extract', *Journal of photochemistry and photobiology. B, Biology*, 197, p. 111531.
 42. Ramadurai, N. et al. (2019) 'Effectiveness of 2% Articaine as an anesthetic agent in children: randomized controlled trial', *Clinical oral investigations*, 23(9), pp. 3543–3550.
 43. Ramakrishnan, M., Dhanalakshmi, R. and Subramanian, E. M. G. (2019) 'Survival rate of different fixed posterior space maintainers used in Paediatric Dentistry - A systematic review', *The Saudi dental journal*, 31(2), pp. 165–172.
 44. Ramamoorthi, S., Nivedhitha, M. S. and Divyanand, M. J. (2015) 'Comparative evaluation of postoperative pain after using endodontic needle and EndoActivator during root canal irrigation: A randomised controlled trial', *Australian Endodontic Journal*, pp. 78–87. doi: 10.1111/aej.12076.
 45. Ramanathan, S. and Solete, P. (2015) 'Cone-beam Computed Tomography Evaluation of Root Canal Preparation using Various Rotary Instruments: An in vitro Study', *The Journal of Contemporary Dental Practice*, pp. 869–872. doi: 10.5005/jp-journals-10024-1773.
 46. Ramesh, A. et al. (2018) 'Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study', *Journal of periodontology*, 89(10), pp. 1241–1248.
 47. Ramesh, S., Teja, K. and Priya, V. (2018) 'Regulation of matrix metalloproteinase-3 gene expression in inflammation: A molecular study', *Journal of Conservative Dentistry*, p. 592. doi: 10.4103/jcd.jcd_154_18.
 48. Ravinthar, K. and Jayalakshmi (2018) 'Recent Advancements in Laminates and Veneers in Dentistry', *Research Journal of Pharmacy and Technology*, p. 785. doi: 10.5958/0974-360x.2018.00148.8.
 49. R, R., Rajakeerthi, R. and Ms, N. (2019) 'Natural Product as the Storage medium for an avulsed tooth – A Systematic Review', *Cumhuriyet Dental Journal*, pp. 249–256. doi: 10.7126/cumudj.525182.
 50. Rudrapati, L. et al. (2017) 'Incremental techniques in direct composite restoration', *Journal of Conservative Dentistry*, p. 386. doi: 10.4103/jcd.jcd_157_16.
 51. Samuel, S. R., Acharya, S. and Rao, J. C. (2020) 'School Interventions-based Prevention of Early-Childhood Caries among 3-5-year-old children from very low socioeconomic status: Two-year randomized trial', *Journal of public health dentistry*, 80(1), pp. 51–60.
 52. Santhosh, L., Bashetty, K. and Nadig, G. (2008) 'The influence of different composite placement techniques on microleakage in preparations with high C- factor: An in vitro study', *Journal of Conservative Dentistry*, p. 112. doi: 10.4103/0972-0707.45249.
 53. Sarfi, S., Bali, D. and Grewal, M. (2017) 'Effect of different layering techniques on microleakage of

- nanofilled composite in class i restorations: An In Vitro study', *Journal of the International Clinical Dental Research Organization*, p. 8. doi: 10.4103/2231-0754.194289.
54. Schneider, L. F. and Moraes, R. R. (2018) 'Polymerization Shrinkage Stress', *Dental Composite Materials for Direct Restorations*, pp. 219–233. doi: 10.1007/978-3-319-60961-4_14.
 55. Sharma, P. et al. (2019) 'Emerging trends in the novel drug delivery approaches for the treatment of lung cancer', *Chemico-biological interactions*, 309, p. 108720.
 56. Shenoy, A. (2008) 'Is it the end of the road for dental amalgam? A critical review', *Journal of Conservative Dentistry*, p. 99. doi: 10.4103/0972-0707.45247.
 57. Siddique, R. et al. (2019) 'Qualitative and quantitative analysis of precipitate formation following interaction of chlorhexidine with sodium hypochlorite, neem, and tulsi', *Journal of conservative dentistry: JCD*, 22(1), pp. 40–47.
 58. Sridharan, G. et al. (2019) 'Evaluation of salivary metabolomics in oral leukoplakia and oral squamous cell carcinoma', *Journal of oral pathology & medicine: official publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology*, 48(4), pp. 299–306.
 59. Teja, K. V. and Ramesh, S. (2019) 'Shape optimal and clean more', *Saudi Endodontic Journal*, 9(3), p. 235.
 60. Varghese, S. S., Ramesh, A. and Veeraiyan, D. N. (2019) 'Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students', *Journal of dental education*, 83(4), pp. 445–450.
 61. Vijayashree Priyadharsini, J. (2019) 'In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens', *Journal of periodontology*, 90(12), pp. 1441–1448.
 62. Vishnu Prasad, S. et al. (2018) 'Report on oral health status and treatment needs of 5-15 years old children with sensory deficits in Chennai, India', *Special care in dentistry: official publication of the American Association of Hospital Dentists, the Academy of Dentistry for the Handicapped, and the American Society for Geriatric Dentistry*, 38(1), pp. 58–59.
 63. Wahab, P. U. A. et al. (2018) 'Scalpel Versus Diathermy in Wound Healing After Mucosal Incisions: A Split-Mouth Study', *Journal of oral and maxillofacial surgery: official journal of the American Association of Oral and Maxillofacial Surgeons*, 76(6), pp. 1160–1164.
 64. Weinmann, W., Thalacker, C. and Guggenberger, R. (2005) 'Siloranes in dental composites', *Dental Materials*, pp. 68–74. doi: 10.1016/j.dental.2004.10.007.
 65. Yoshida, Y. et al. (2008) 'Dental adhesives and adhesive performance', *Dental biomaterials*. doi: 10.1201/9781439832684.ch4.