JOURNAL OF NORTHEASTERN UNIVERSITY

Volume 25 Issue 04, 2022 ISSN: 1005-3026 https://dbdxxb.cn/ Original Research Paper

KNOWLEDGE, AWARENESS AND PRACTISES ON APPLICATIONS OF NANOPARTICLES IN ENDODONTICS AMONG UNDERGRADUATE DENTAL STUDENTS - A QUESTIONNAIRE SURVEY

Running title - Knowledge, awareness and practices on nanoparticles in endodontics among undergraduate dental students

Type of study - Survey

Malavika Pradeep
Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai – 600077, Email : 151901064.sdc@saveetha.com

Raghu Sandhya
Reader, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai – 600077, Mail ID: sandhya.sdc@saveetha.com

Adimulapu Hima Sandeep
Associate Professor, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai – 600077
Mail ID: himas.sdc@saveetha.com

Sources of Support/Financial funding- Nil

Word count- 2493 [Excluding Abstract and References]

Number of figures and Tables- 7 Graphs

Conflict of interest- Nil

ABSTRACT -

Introduction: Endodontic disease is a biofilm facilitated infection, and the fundamental objective in its treatment is the removal of these biofilms from the endodontic canals. Nanoparticles offer unique physicochemical properties, such as ultrasmall sizes, large surface area/mass ratio, and increased chemical reactivity, compared with their bulk counterparts.

Aim: The aim of the present study is to assess knowledge, attitude and practice of nanoparticles in endodontics among dental students.

Materials and method: The data collection software used is google forms. The data were represented in the form of a bar graph. The statistical software used was SPSS software . The statistical test used in the present study is Chi square test and the type of analysis used in this

Submitted: 08/12/2022 **Accepted**: 27/12/2022

study was descriptive analysis. The steps followed in software analysis are data collection, data analysis and data interpretation.
Result: 44% of the dental students think that nanotechnology is useful in management of endodontic diseases by drug delivery. 57 % of the dental students were aware that the nanoparticles have biomedical applications in drug delivery, antimicrobial application, and in imaging. 68% are aware of the importance of nanoparticles in endodontics. Gender did not influence the knowledge of nanoparticles in dentistry. (Chi square test, p values - 0.07,0.06).
Conclusion: Within the limitations of the study it can be concluded that the majority of the dental students were aware of the importance of nanoparticles in endodontics. By imparting further knowledge on the choice of nanomaterial, mode of delivery, its biocompatibility among the dental students can provide scope for its routine clinical application.
Keywords : Nanoparticles, drug delivery, endodontics, antimicrobial

INTRODUCTION -

Nanoparticles have a long and illustrious history of modern science. In 1959, Dr. Richard Feynman proposed the concept of nanotechnology. Dr. Freitas Jr. invented the phrase "nano-dentistry" in the year 2000. He developed nanomaterials and nanorobots, helped in regeneration of dentition, and developed dentin robots – robots in dentifrices. Many of these concepts were once thought to be impractical and labelled as "science fiction," but they are now being understood by physicians in the modern age. Nanoparticles offer unique physicochemical properties, such as ultrasmall sizes, large surface area/mass ratio, and increased chemical reactivity, compared with their bulk counterparts (1) (2). Nanotechnology has progressed rapidly in science and technology, creating a myriad of biomedical applications such as drug delivery, tissue regeneration, antimicro- bial application, gene transfection, and imaging (3) (4). Nanoparticles are further categorized as organic or inor- ganic in nature. They are known as particles, circles, tubes, rods, plates, and so on based on their shape.

Functionalized nanoparticles have a single-material core with additional molecules or proteins bound to its surface or encapsulated inside them. Depending on the specific applications, nanoparticles can be functionalized with pep- tides, drugs, photosensitizers, and so on (5)(6). In root canal therapy, the main objectives are the patho- logical pulp removal, root canal system cleaning and shaping, contam- inated root canals disinfection, and root canal system obturation in three dimensions in order to avoid reinfection (7). According to the European Commission's Recommendation, a "nanomaterial" is a normal, incidental, or manufactured material that contains particles in an unbound state, as an aggregate, or as an agglomerate, with one or more external dimensions in the range of 1–100 nm for 50% or more of the particles in the number size distribution (8). Antimicrobial nanoparticles with various advantages such as high surface-area-to-volume ratio, ultra-small sizes, and excellent chemical and physical properties have been introduced to address the disadvantages of traditional antibacterial agents and to achieve promising results in endodontics. The oral cavity is home to the majority of microorganisms (9). Majority of microorganisms are inhabitants of the oral cavity (10).

Endodontic disease is a biofilm-facilitated infection, and the elimination of these biofilms from the endodontic canals is the primary aim of treatment. Biofilms are microorganism aggregations that are frequently embedded in a self-produced matrix of extracellular polymeric substances (EPS) that are adherent to each other and/or a surface (11). Various experiments focusing on antibacterial means to solve this problem have been conducted, but most of the studies have failed to produce the desired results due to the rapid release and degradation of antibacterial agents, resulting in inefficiency and safety alarms (12)(13). Our team has extensive knowledge and research experience that has translate into high quality publications(14–23),(24–27),(28–32) (33). As antibacterial agents, NPs use a variety of processes that are distinct from antimicrobial processes used in other conventional medicines. Nanoparticles provide more benefits since they are less stable, have less bonding, and interact with other molecules. Furthermore, due to the high surface area to volume ratio the energy statistics of the particles is established (13)(34). The aim of the present study is to analyze awareness of nanoparticles in endodontics among dental populations.

MATERIALS AND METHODS -

A cross sectional study was conducted among undergraduate dental students in a dental institution. This was done in the form of a questionnaire that was circulated online. The dental students were of the age group 18 to 25 years. The study protocol was approved by the institutional review board and the questionnaire was validated. The sample size of this study was 100. The questionnaire consisted of 13 questions that mainly focused on knowledge, awareness and practices on nanoparticles in endodontics among undergraduate dental students. The questionnaire was distributed among the students through an online survey website called google forms. The data was collected, compiled and was arranged in a systematic manner and was analysed according to SPSS software. The independent variable of the study was gender. The results were then represented in the form of pie charts and bar charts.

Inclusion criteria:

The participants should be dental students.

Exclusion criteria:

Students who were not available to take the survey.
Students who were not willing to participate.
Dentists who had completed the period of study.

Study Setting:

The study was conducted with the approval of the Institutional Ethics Committee. The study consisted of one assessor and one guide .

Study method:

Self administered questionnaire of 13 close-ended questions was prepared and was validated by the Institutional Review Board(IRB). The questionnaire was distributed among undergraduate dental college students of private dental college institutions through an online survey form "GOOGLE FORMS" . Demographic details were also included in the questionnaire.

Sampling Technique:

The study was based on a non probability consecutive sampling method.

Ethical considerations:

Returning the filled questionnaire was considered as implicit consent with no need for signing for a return consent. Ethical approval of study is obtained from the Institutional Review Board (IRB).

Statistical analysis:

Data was analysed with the SPSS version (22.0). Descriptive statistics as number and percent were calculated to summarize qualitative data. Chi square test was used to analyze and compare the education level of students and their knowledge, attitude and practise on armamentarium for endodontic surgery among undergraduate dental students. Finally the results were represented by using bar charts and frequency tables.

RESULT -

58% of the respondents are female and 42% of the respondents are male. 51% of the respondents are ph students and 49% of the students are ug students. 40% of the respondents have responded that nanoparticles can improve endodontic and prosthodontic field with nano composite denture teeth, 24% of the respondents responded that nanoparticles can improve endodontic and prosthodontic field with endodontic sealers, 15% responded that nanoparticles can improve endodontic and prosthodontic field with impression materials and 21% responded that with root canal disinfection nanoparticles can improve endodontic and prosthodontic field. 9% of the respondents responded that nanoparticles are already being used in toothpaste, 14% responded mouthwash, 33% responded resin composite and 44% responded bonding systems. 31% of the respondents did not agree that nanoparticles can be more toxic than larger particles of the same material and 69% of the respondents agreed that nanoparticles can be more toxic than the larger particles of the same material.

43% of the respondents responded that size of the nanoparticles are 1-100 nm, 39% of the respondents responded that size of the nanoparticles are 2-200 nm and 18% of the respondents responded that size of the nanoparticles are 3-300 nm. 17% of the respondents responded that biomedical applications of nanoparticles are antimicrobial applications, 8%of the respondents responded that it is drug delivery, 18% of the respondents responded that it is imaging and 57% of the respondents responded that it is all. 7% of the respondents responded that liposomes are the drug used in nanoparticles used in drug delivery system, 29% of the respondents responded

dendrimers, 15% of the respondents responded polymeric micelles, 43% of the respondents responded all and 10% of the respondents responded none.
66% of the respondents think that glass ionomer cement used in nanotechnology is useful in endodontic sealers and 34% of the respondents responded that glass ionomer cement cannot be used in endodontic sealers. 53% of the respondents responded that chitosan nanoparticles can not be used as drug carriers and 47% of the respondents responded that chitosan nanoparticles can be used as drug carriers. 44% of the respondents responded that nanotechnology is useful in management of endodontic diseases by drug delivery, 18% of the respondents responded that nanotechnology is not useful in management of endodontic diseases by drug delivery and 38 % of the respondents responded that they are not sure.
66% of the respondents responded that they were aware of the importance of nanoparticles in endodontics and 32% of the respondents responded that they are not aware of the importance of nanoparticles in endodontics. 62% of the respondents responded that the survey was helpful in making them analyze or know the importance of nanoparticles in endodontics and 38% of thenrespondemts responded that the survey was helpful in making them analyze or know importance of nanoparticles in endodontics.

TABLE 1 - REPRESENTING RESPONSES OF THE STUDY POPULATION TO THE QUESTIONNAIRE

S. NO	QUESTIONS	CHOICES	RESPONSES
1.	What is your gender?	• Male • Female	42% 58%
2.	UG or PG student ?	• UG student • PG student	49% 51%
3.	Nanoparticles can improve the endodontic and prosthodontic application with ___	• Endodontic sealers • Root canal disinfection • Impression materials • Nanocomposite denture teeth	24% 21% 15% 40%
4.	Nanoparticles are already being used in ___	• Toothpaste • Mouthrinsers • Resin composite • Bonding systems	9% 14% 33% 44%
5.	State true or false. “Nanoparticles can be	• True • False	69% 31%

	more toxic than the larger particles of the same material"		
6.	What is the size of nanoparticles?	● 1-100 nm ● 200 nm ● 300 nm	43% 39% 18%
7.	What are the biomedical applications of nanoparticles ?	● Antimicrobial applications ● Drug delivery ● Imaging ● All	17% 8% 18% 57%
8.	Nanoparticles used in drug delivery systems are ?	● Liposomes ● Dendrimes ● Polymeric micelles ● All ● None	3% 29% 15% 43% 10%
9.	Do you think glass ionomer cement used in nano technology is useful in endodontic sealers ?	● Yes ● No	66% 34%
10.	State true or false. "Chitosan nanoparticles can be used as drug carrier"	● True ● False	47% 53%
11.	Do you think nanotechnology is useful in management of endodontic diseases by drug delivery?	● Yes ● No ● Not sure	44% 18% 38%
12.	Were you aware of the importance of nanoparticles in endodontics?	● Yes ● No	68% 32%

13.	Was this survey helpful in making you analyze or know the importance of nanoparticles in endodontics?	• Yes • No	62% 38%

DISCUSSION -

In the present study, 53% of the respondents responded that chitosan nanoparticles can not be used as drug carriers and 47% of the respondents responded that chitosan nanoparticles can be used as drug carriers (Figure 4). Chitosan is the second most abundant natural biopolymer and can be chemically changed. It is a deacetylated derivative of chitin. Chitosan possesses outstanding antibacterial, antifungal, and antiviral properties. Chitosan NPs' method of action is based on the principle of electrostatic contact, which causes cell membrane breakdown.This results in increased permeability of cell wall, eventually causing cell death and microleakage of its intracellular components (35).

Kishen et al. were the first in the field of Nanoparticles to test the effectiveness of Chitosan NPs in root canal disinfection. Because of its concentration and time-dependent property, chitosan may penetrate the complexity of the root canal and dentinal tubules, eradicating germs even after 3 months (36). In an in-vitro investigation, Barreras US et al. employed Chitosan Nanoparticles in combination with CHX to eliminate Enterococcus faecalis from the canals. Membrane barriers formed at the peri-radicular area as a result of this combination. (37) .

In the present study 40% of the respondents have responded that nanoparticles can improve endodontic and prosthodontic field with nano composite denture teeth, 24% of the respondents responded that nanoparticles can improve endodontic and prosthodontic field with endodontic sealers, 15% responded that nanoparticles can improve endodontic and prosthodontic field with impression materials and 21% responded that with root canal disinfection nanoparticles can improve endodontic and prosthodontic field (Figure 1). A correlation graph which depicts the association between gender and the responses of the respondents regarding the use of nanoparticles in improving the endodontic and prosthodontic field was also done (Figure 6). Majority of the males (26%) have responded that nanoparticles can improve the endodontic and prosthodontic field with nano composite denture. Majority of the females (18%) have responded that nanoparticles can improve the endodontic and prosthodontic field with root canal disinfection. A correlation graph which depicts the association between gender and the responses of the respondents regarding the use of nanoparticles. (Figure 7) Majority of the males (16%) have responded that nanoparticles are already being used in resin composite. Majority of the females (32%) have responded that nanoparticles are already being used in bonding systems.

The antibacterial properties of silver compounds and nanoparticles make them popular in biomedicine. Silver and its nanoparticles have been studied as endodontic retrograde filling material, dental restorative material, dental implants, and caries inhibitory solution in the dentistry field (38)(39). The majority of nanoparticles studied for root canal disinfection have antibacterial activity that is time-dependent and contact-mediated. By inhibiting biofilm formation on the surface as well as at the resin-dentin interface, adding different nanoparticles to root filling materials sealers or considerably increased antibacterial activity (40) (41).

In the present study, 44% of the respondents responded that nanotechnology is useful in management of endodontic diseases by drug delivery, 18% of the respondents responded that nanotechnology is not useful in management of endodontic diseases by drug delivery and 38 % of the respondents responded that they are not sure. Poly (lactic) co-glycolic acid Nanoparticles incorporated with photoactive drugs are used as an essential adjunct in the eradication of microorganisms from endodontic canals. The combination of these methylene blue filled NPs and light are used to reduce microbial counts adhered to the root dentin and canals. It is one of the most significant NPs used in endodontic treatment.(42)(43)(44)(45)

With each passing year, the impact of nanoparticles in dentistry, particularly endodontics, for the treatment of numerous oral illnesses grows exponentially. Due to their superior physical, mechanical, chemical, and biological capabilities, nanomaterials (NMs) have lately gained relevance in technological breakthroughs. When compared to their conventional counterparts, these features have resulted in improved performance. Nanomaterials have showed promise in reducing biofilm development, enhancing remineralization of tooth structure by limiting demineralization, and combating caries-related and endodontic bacteria. These findings have piqued the interest of researchers who want to conduct more clinical trials to verify the therapeutic efficacy of nanotechnology-based materials. Nanotechnology has left an indelible mark on nearly every aspect of research and development.

Naturally, this technology with great promise has influenced medicine and dentistry as well. Having said that, there is little doubt that the future of endodontics will be nano-focused, as the majority of the issues faced (microorganisms, dentin) are all nano-sized. The era of nano-endodontics is paving the way for dentistry's bright future. In the present study , the sample size is 100 which is less. In future more people can be included in the study that is more sample size. In the present study only the dental population are taken into consideration. In future different groups of population can be included . Including more population can create more awareness. People will look into this topic more seriously.

CONCLUSION -

Within the limitations of the study it can be concluded that the majority of the dental students were aware of the importance of nanoparticles in endodontics. By imparting further knowledge

on the choice of nanomaterial, mode of delivery, its biocompatibility among the dental students can provide scope for its routine clinical application.

CONFLICT OF INTEREST: The author declares that there was no conflict of interest in the present study.

ACKNOWLEDGEMENT: We thank Saveetha Dental College for supporting us to conduct the study.

REFERENCE -

1. Cohen ML. Nanotubes, Nanoscience, and Nanotechnology [Internet]. Vol. 15, Materials Science and Engineering: C. 2001. p. 1–11. Available from: http://dx.doi.org/10.1016/s0928-4931(01)00221-1

2. Glass NL, Louise Glass N. Book Review: R. Maheshwari, Fungi: Experimental Methods in Biology, CRC Press, Taylor and Francis, Boca Raton, FL, USA. 2005, 240 pp., $149.95 [Internet]. Vol. 161, Mycopathologia. 2006. p. 341–2. Available from: http://dx.doi.org/10.1007/s11046-006-0006-0l

3. Venugopal J, Prabhakaran M, Low S, Choon A, Zhang Y, Deepika G, et al. Nanotechnology for Nanomedicine and Delivery of Drugs [Internet]. Vol. 14, Current Pharmaceutical Design. 2008. p. 2184–200. Available from: http://dx.doi.org/10.2174/138161208785740180

4. Cushing BL, Kolesnichenko VL, O'Connor CJ. Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles [Internet]. Vol. 104, Chemical Reviews. 2004. p. 3893–946. Available from: http://dx.doi.org/10.1021/cr030027b

5. Veerapandian M, Yun K. Functionalization of biomolecules on nanoparticles: specialized for antibacterial applications [Internet]. Vol. 90, Applied Microbiology and Biotechnology. 2011. p. 1655–67. Available from: http://dx.doi.org/10.1007/s00253-011-3291-6

6. Liu L, Xu K, Wang H, Jeremy Tan PK, Fan W, Venkatraman SS, et al. Self-assembled cationic peptide nanoparticles as an efficient antimicrobial agent [Internet]. Vol. 4, Nature Nanotechnology. 2009. p. 457–63. Available from: http://dx.doi.org/10.1038/nnano.2009.153

7. Torabinejad M, Kutsenko D, Machnick TK, Ismail A, Newton CW. Levels of Evidence for the Outcome of Nonsurgical Endodontic Treatment [Internet]. Vol. 31, Journal of Endodontics. 2005. p. 637–46. Available from: http://dx.doi.org/10.1097/01.don.0000153593.64951.14

8. Paik S, Sechrist C, Torabinejad M. Levels of Evidence for the Outcome of Endodontic

Retreatment [Internet]. Vol. 30, Journal of Endodontics. 2004. p. 745–50. Available from: http://dx.doi.org/10.1097/01.don.0000137636.93933.51

9. Saafan A, Zaazou MH, Sallam MK, Mosallam O, El Danaf HA. Assessment of Photodynamic Therapy and Nanoparticles Effects on Caries Models [Internet]. Vol. 6, Open Access Macedonian Journal of Medical Sciences. 2018. p. 1289–95. Available from: http://dx.doi.org/10.3889/oamjms.2018.241

10. Kasraei S, Sami L, Hendi S, AliKhani M-Y, Rezaei-Soufi L, Khamverdi Z. Antibacterial properties of composite resins incorporating silver and zinc oxide nanoparticles onStreptococcus mutansandLactobacillus [Internet]. Vol. 39, Restorative Dentistry & Endodontics. 2014. p. 109. Available from: http://dx.doi.org/10.5395/rde.2014.39.2.109

11. Fernandes GL, Delbem ACB, do Amaral JG, Gorup LF, Fernandes RA, de Souza Neto FN, et al. Nanosynthesis of Silver-Calcium Glycerophosphate: Promising Association against Oral Pathogens. Antibiotics (Basel) [Internet]. 2018 Jun 27;7(3). Available from: http://dx.doi.org/10.3390/antibiotics7030052

12. Thakur VK, Thakur MK. Eco-friendly Polymer Nanocomposites: Chemistry and Applications. Springer; 2015. 576 p.

13. Roduner E. Size matters: why nanomaterials are different. Chem Soc Rev. 2006 Jul;35(7):583–92.

14. Muthukrishnan L. Imminent antimicrobial bioink deploying cellulose, alginate, EPS and synthetic polymers for 3D bioprinting of tissue constructs. Carbohydr Polym. 2021 May 15;260:117774.

15. PradeepKumar AR, Shemesh H, Nivedhitha MS, Hashir MMJ, Arockiam S, Uma Maheswari TN, et al. Diagnosis of Vertical Root Fractures by Cone-beam Computed Tomography in Root-filled Teeth with Confirmation by Direct Visualization: A Systematic Review and Meta-Analysis. J Endod. 2021 Aug;47(8):1198–214.

16. Chakraborty T, Jamal RF, Battineni G, Teja KV, Marto CM, Spagnuolo G. A Review of Prolonged Post-COVID-19 Symptoms and Their Implications on Dental Management. Int J Environ Res Public Health [Internet]. 2021 May 12;18(10). Available from: http://dx.doi.org/10.3390/ijerph18105131

17. Muthukrishnan L. Nanotechnology for cleaner leather production: a review. Environ Chem Lett. 2021 Jun 1;19(3):2527–49.

18. Teja KV, Ramesh S. Is a filled lateral canal - A sign of superiority? J Dent Sci. 2020 Dec;15(4):562–3.

19. Narendran K, Jayalakshmi, Ms N, Sarvanan A, Ganesan S A, Sukumar E. Synthesis, characterization, free radical scavenging and cytotoxic activities of phenylvilangin, a substituted dimer of embelin. ijps [Internet]. 2020;82(5). Available from: https://www.ijpsonline.com/articles/synthesis-characterization-free-radical-scavenging-and-cytotoxic-activities-of-phenylvilangin-a-substituted-dimer-of-embelin-4041.html

20. Reddy P, Krithikadatta J, Srinivasan V, Raghu S, Velumurugan N. Dental Caries Profile and Associated Risk Factors Among Adolescent School Children in an Urban South-Indian City. Oral Health Prev Dent. 2020 Apr 1;18(1):379–86.

21. Sawant K, Pawar AM, Banga KS, Machado R, Karobari MI, Marya A, et al. Dentinal Microcracks after Root Canal Instrumentation Using Instruments Manufactured with Different NiTi Alloys and the SAF System: A Systematic Review. NATO Adv Sci Inst Ser E Appl Sci. 2021 May 28;11(11):4984.

22. Bhavikatti SK, Karobari MI, Zainuddin SLA, Marya A, Nadaf SJ, Sawant VJ, et al. Investigating the Antioxidant and Cytocompatibility of Mimusops elengi Linn Extract over Human Gingival Fibroblast Cells. Int J Environ Res Public Health [Internet]. 2021 Jul 4;18(13). Available from: http://dx.doi.org/10.3390/ijerph18137162

23. Karobari MI, Basheer SN, Sayed FR, Shaikh S, Agwan MAS, Marya A, et al. An In Vitro Stereomicroscopic Evaluation of Bioactivity between Neo MTA Plus, Pro Root MTA, BIODENTINE & Glass Ionomer Cement Using Dye Penetration Method. Materials [Internet]. 2021 Jun 8;14(12). Available from: http://dx.doi.org/10.3390/ma14123159

24. Rohit Singh T, Ezhilarasan D. Ethanolic Extract of Lagerstroemia Speciosa (L.) Pers., Induces Apoptosis and Cell Cycle Arrest in HepG2 Cells. Nutr Cancer. 2020;72(1):146–56.

25. Ezhilarasan D. MicroRNA interplay between hepatic stellate cell quiescence and activation. Eur J Pharmacol. 2020 Oct 15;885:173507.

26. Romera A, Peredpaya S, Shparyk Y, Bondarenko I, Mendonça Bariani G, Abdalla KC, et al. Bevacizumab biosimilar BEVZ92 versus reference bevacizumab in combination with FOLFOX or FOLFIRI as first-line treatment for metastatic colorectal cancer: a multicentre, open-label, randomised controlled trial. Lancet Gastroenterol Hepatol. 2018 Dec;3(12):845–55.

27. Raj R K, D E, S R. β-Sitosterol-assisted silver nanoparticles activates Nrf2 and triggers mitochondrial apoptosis via oxidative stress in human hepatocellular cancer cell line. J Biomed Mater Res A. 2020 Sep;108(9):1899–908.

28. Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. J Periodontol. 2019 Dec;90(12):1441–8.

29. Priyadharsini JV, Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen A. baumannii and related species [Internet]. Vol. 94, Archives of Oral Biology. 2018. p. 93–8. Available from: http://dx.doi.org/10.1016/j.archoralbio.2018.07.001

30. Uma Maheswari TN, Nivedhitha MS, Ramani P. Expression profile of salivary micro RNA-21 and 31 in oral potentially malignant disorders. Braz Oral Res. 2020 Feb 10;34:e002.

31. Gudipaneni RK, Alam MK, Patil SR, Karobari MI. Measurement of the Maximum Occlusal Bite Force and its Relation to the Caries Spectrum of First Permanent Molars in Early Permanent Dentition. J Clin Pediatr Dent. 2020 Dec 1;44(6):423–8.

32. Chaturvedula BB, Muthukrishnan A, Bhuvaraghan A, Sandler J, Thiruvenkatachari B. Dens invaginatus: a review and orthodontic implications. Br Dent J. 2021 Mar;230(6):345–50.

33. Kanniah P, Radhamani J, Chelliah P, Muthusamy N, Joshua Jebasingh Sathiya Balasingh E, Reeta Thangapandi J, et al. Green synthesis of multifaceted silver nanoparticles using the flower extract of Aerva lanata and evaluation of its biological and environmental applications. ChemistrySelect. 2020 Feb 21;5(7):2322–31.

34. Aeran H, Kumar V, Uniyal S, Tanwer P. Nanodentistry: Is just a fiction or future [Internet]. Vol. 5, Journal of Oral Biology and Craniofacial Research. 2015. p. 207–11. Available from: http://dx.doi.org/10.1016/j.jobcr.2015.06.012

35. Shrestha A, Zhilong S, Gee NK, Kishen A. Nanoparticulates for Antibiofilm Treatment and Effect of Aging on Its Antibacterial Activity [Internet]. Vol. 36, Journal of Endodontics. 2010. p. 1030–5. Available from: http://dx.doi.org/10.1016/j.joen.2010.02.008

36. Lee D-K, Kim SV, Limansubroto AN, Yen A, Soundia A, Wang C-Y, et al. Nanodiamond–Gutta Percha Composite Biomaterials for Root Canal Therapy [Internet]. Vol. 9, ACS Nano. 2015. p. 11490–501. Available from: http://dx.doi.org/10.1021/acsnano.5b05718

37. Barreras US, Méndez FT, Martínez REM, Valencia CS, Rodríguez PRM, Rodríguez JPL. Chitosan nanoparticles enhance the antibacterial activity of chlorhexidine in collagen membranes used for periapical guided tissue regeneration [Internet]. Vol. 58, Materials Science and Engineering: C. 2016. p. 1182–7. Available from:

http://dx.doi.org/10.1016/j.msec.2015.09.085

38. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: a case study on E. coli as a model for Gram-negative bacteria [Internet]. Vol. 275, Journal of Colloid and Interface Science. 2004. p. 177–82. Available from: http://dx.doi.org/10.1016/j.jcis.2004.02.012

39. García-Contreras R, Argueta-Figueroa L, Mejía-Rubalcava C, Jiménez-Martínez R, Cuevas-Guajardo S, Sánchez-Reyna PA, et al. Perspectives for the use of silver nanoparticles in dental practice. Int Dent J. 2011 Dec;61(6):297–301.

40. Lansdown ABG. Silver in health care: antimicrobial effects and safety in use. Curr Probl Dermatol. 2006;33:17–34.

41. Melo MAS, Guedes SFF, Xu HHK, Rodrigues LKA. Nanotechnology-based restorative materials for dental caries management. Trends Biotechnol. 2013 Aug;31(8):459–67.

42. Guerreiro-Tanomaru JM, Trindade-Junior A, Costa BC, da Silva GF, Cifali LD, Bernardi MIB, et al. Effect of Zirconium Oxide and Zinc Oxide Nanoparticles on Physicochemical Properties and Antibiofilm Activity of a Calcium Silicate-Based Material [Internet]. Vol. 2014, The Scientific World Journal. 2014. p. 1–6. Available from: http://dx.doi.org/10.1155/2014/975213

43. Ranjan, M., Hemmanur, S., Sandeep, A.H." 56111870100;57218922686;57218918668; Survival rate of endodontically treated teeth with custom made cast post-a systematic review 2021International Journal of Dentistry and Oral Science 852574 2580 https://www.scopus.com/inward/record.uri?eid=2-s2.0-85108433104&partnerID=40&md5=c30782cdab11c580c9855985186b7878

44. Behera, K., Sandeep, A.H." 57226154568;57218918668; Dynamic navigation system-a current breakthrough in dentistry 2021 International Journal of Dentistry and Oral Science8529102912 https://www.scopus.com/inward/record.uri?eid=2-s2.0-85110741136&partnerID=40&md5=f5948668f3a2096b4c208e6517fae414 Article FinalScopus 2-s2.0-85110741136

45. Jitesh, S., Sandeep, A.H." 57190564955;57218918668;"Assessment of knowledge, attitude and practice based survey towards rubber dam usage in clinical practice among undergraduate dental students" 2020 International Journal of Pharmaceutical Research122567257410.31838/ijpr/2020.SP1.373 https://www.scopus.com/inward/record.uri?eid=2-s2.0-85090756018&doi=10.31838%2fijpr%2f2020.SP1.373&partnerID=40&md5=b225b9cfcfc75c05a59a151f7fa9ea4d

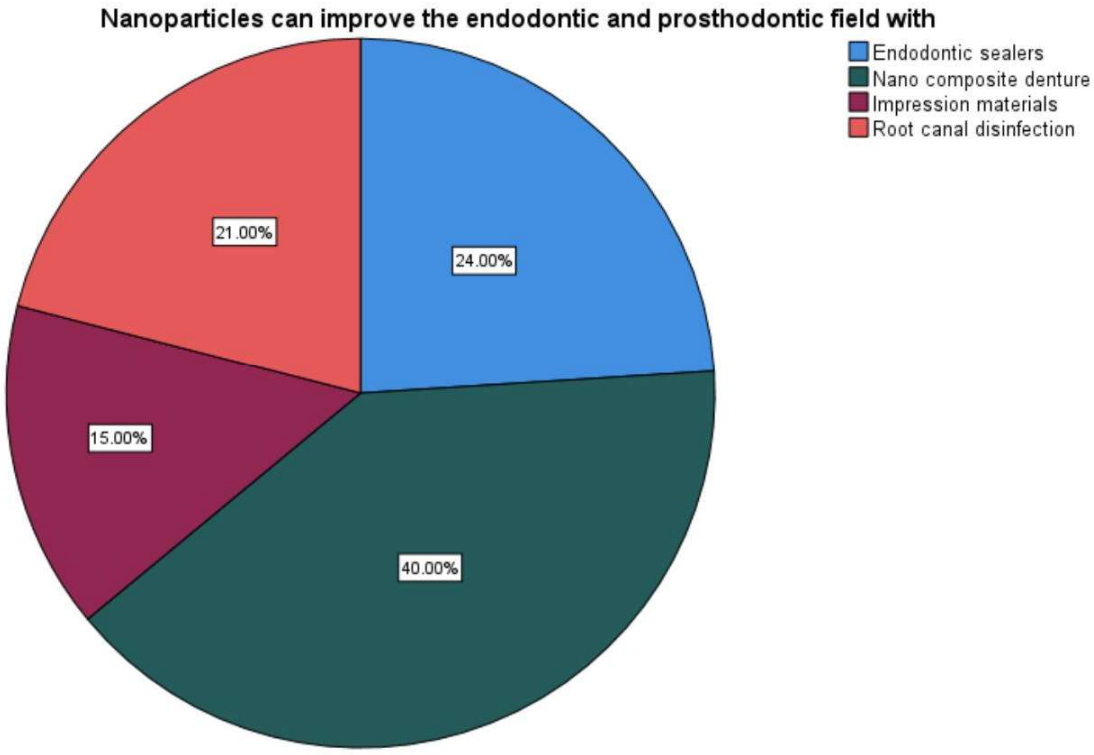

Figure 1 : Pie chart representing knowledge of respondents regarding nanoparticles use in the endodontic and prosthodontic field. 40% (green) of the students were aware that nanoparticles can improve endodontic and prosthodontic fields with nano composite denture teeth. Other students were aware of the improvement related with endodontic sealers (24%, blue) , root canal disinfection (21%, red) and impression materials (15%, pink).

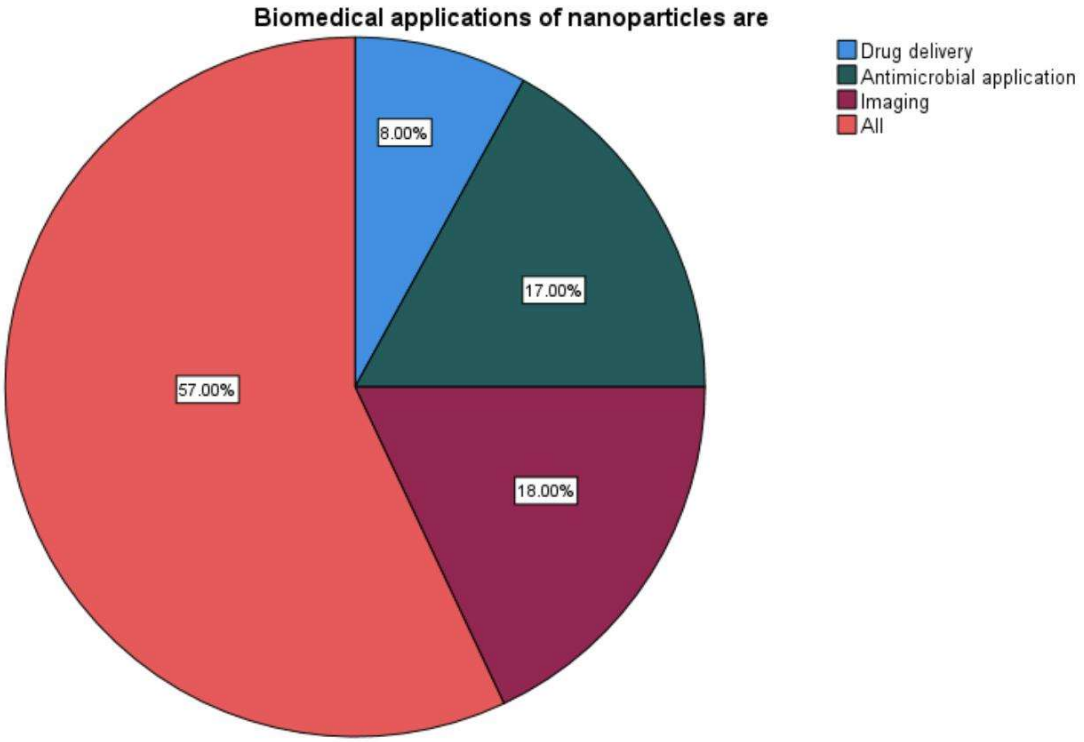

Figure 2: Pie chart representing knowledge of respondents regarding biomedical applications of nanoparticles. 57% (red) of the dental students were aware that the nanoparticles have biomedical applications in drug delivery, antimicrobial application, and in imaging. Other students were aware of their applications either in imaging (18%, pink), or in antimicrobial application (17%, green) or in drug delivery (8%, blue).

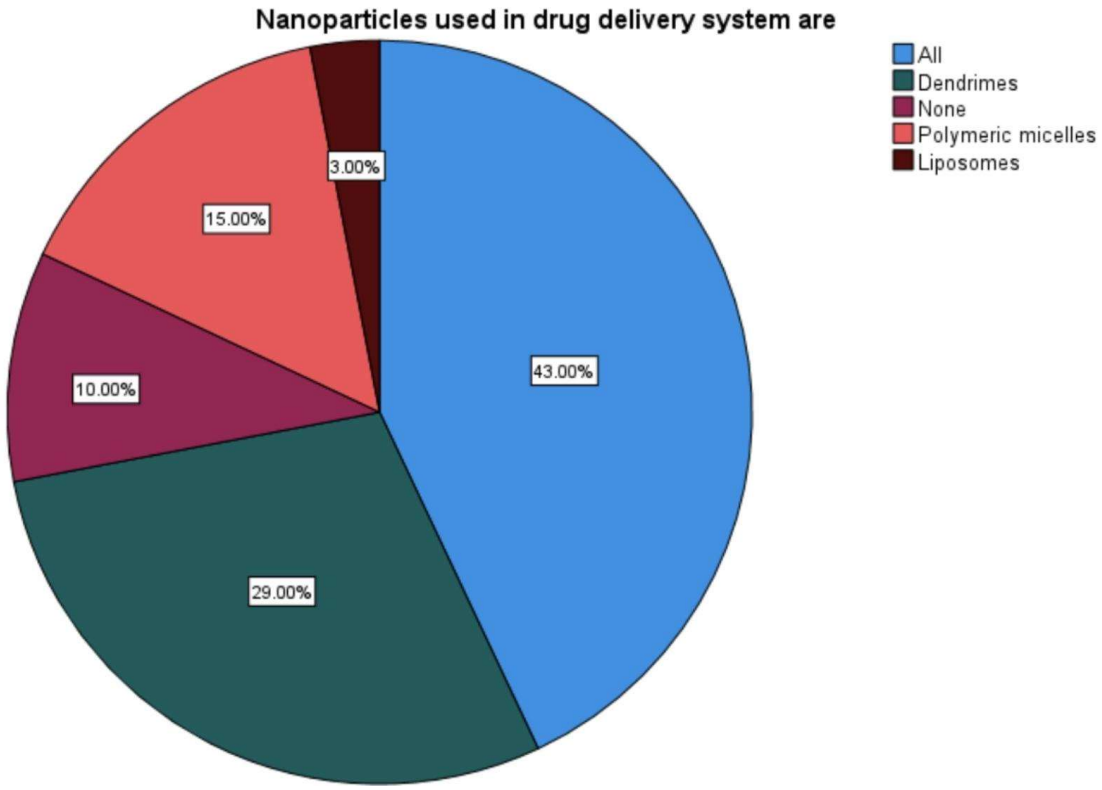

Figure 3: Pie chart representing knowledge of respondents regarding nanoparticles used in drug delivery systems. 43% of the dental students were aware that the nanoparticles used in drug delivery systems are dendrimes, polymeric micelles and liposomes. Other students were aware of the use of dendrimes (29%, green) , polymeric micelles (15%, red) , none of the above (10%, pink) and liposomes (3%, brown) as nanoparticles used in drug delivery system.

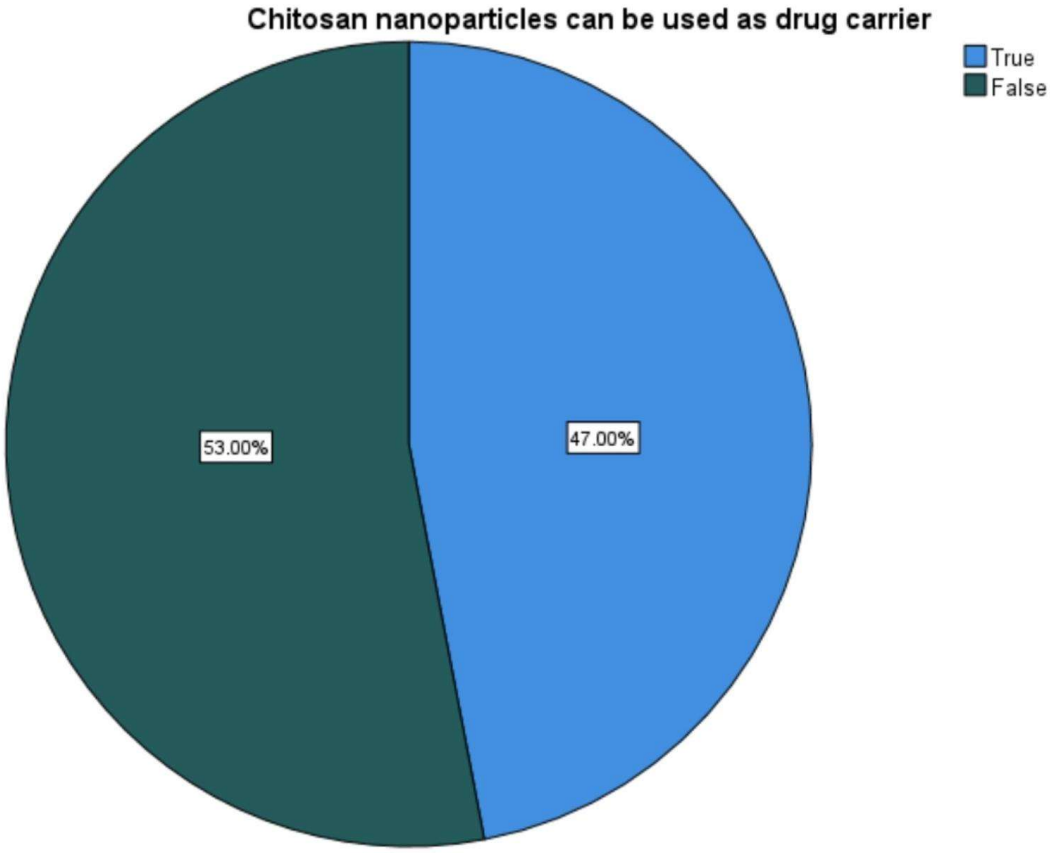

Figure 4: Pie Chart representing the knowledge of respondents regarding the use of chitosan nanoparticles as drug carrier. 53% (green) of the dental students were not aware that chitosan nanoparticles can be used as drug carrier whereas 47% of the students (blue) were aware of it.

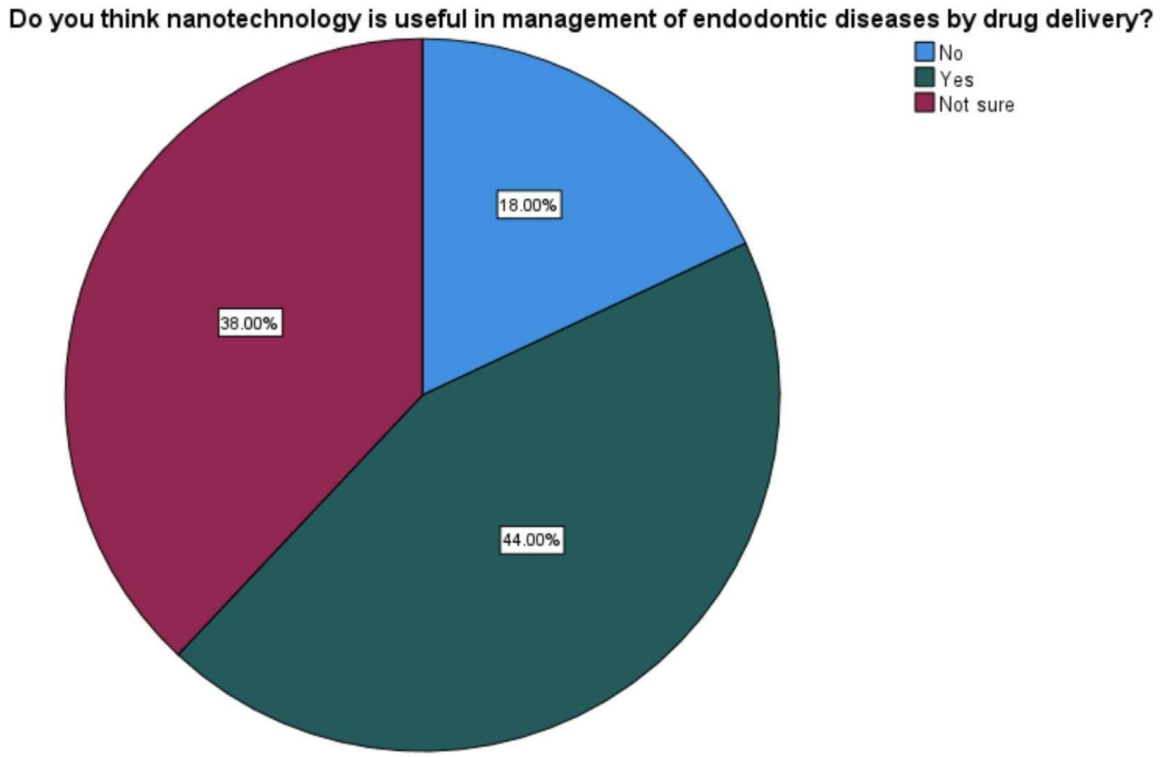

Figure 5: Pie chart representing the knowledge of respondents regarding the use of nanotechnology in management of endodontic disease by drug delivery. 44% (green) of the dental students think that nanotechnology is useful in management of endodontic diseases by drug delivery. Other students were not sure (38%,pink) and did not think (18%,blue) that nanotechnology is useful in management of endodontic diseases by drug delivery.

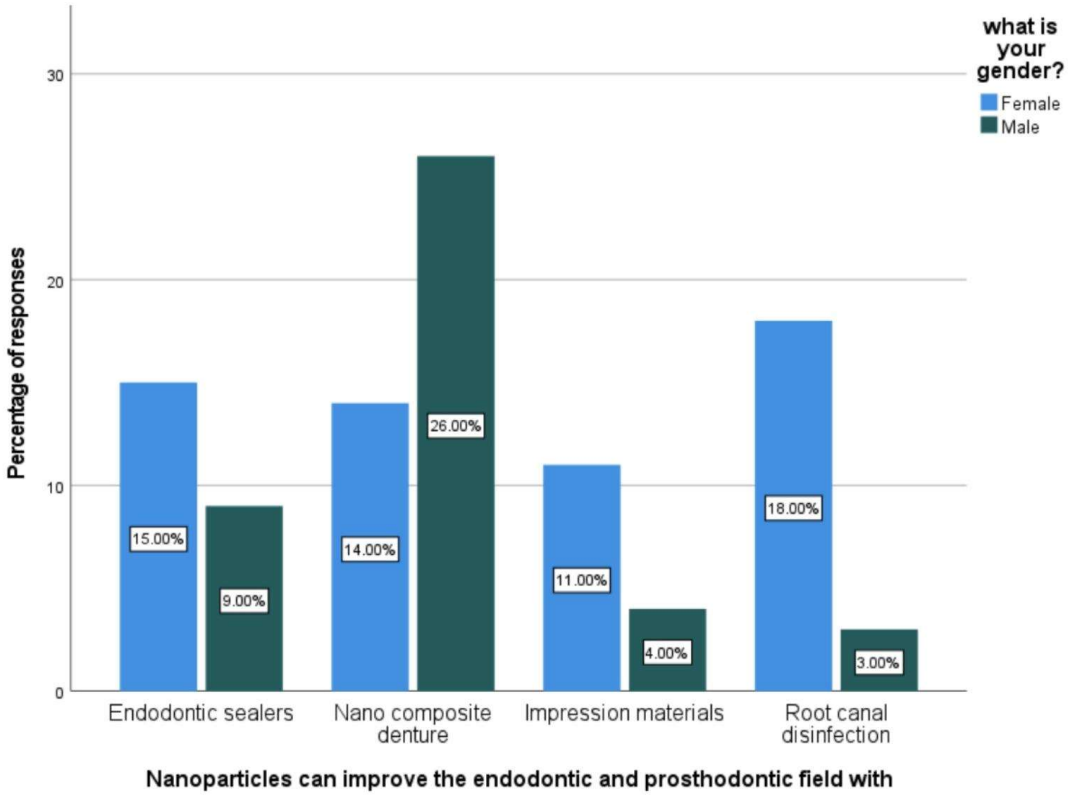

Figure 6: Bar graph depicts the association between gender and the responses of the respondents regarding the use of nanoparticles in improving the endodontic and prosthodontic field. X axis represents the materials nanoparticles can be used to improve the materials used in endodontic and prosthodontic field. Y axis represents the percentage of response. Blue colour indicates female and green colour indicates male. Majority of the males (26%) have responded that nanoparticles can improvise the nano composite denture. Majority of the females (18%) have responded that nanoparticles can improve the root canal disinfection. However the association is not statistically significant (Chi square test, p value =0.07, $p > 0.05$)

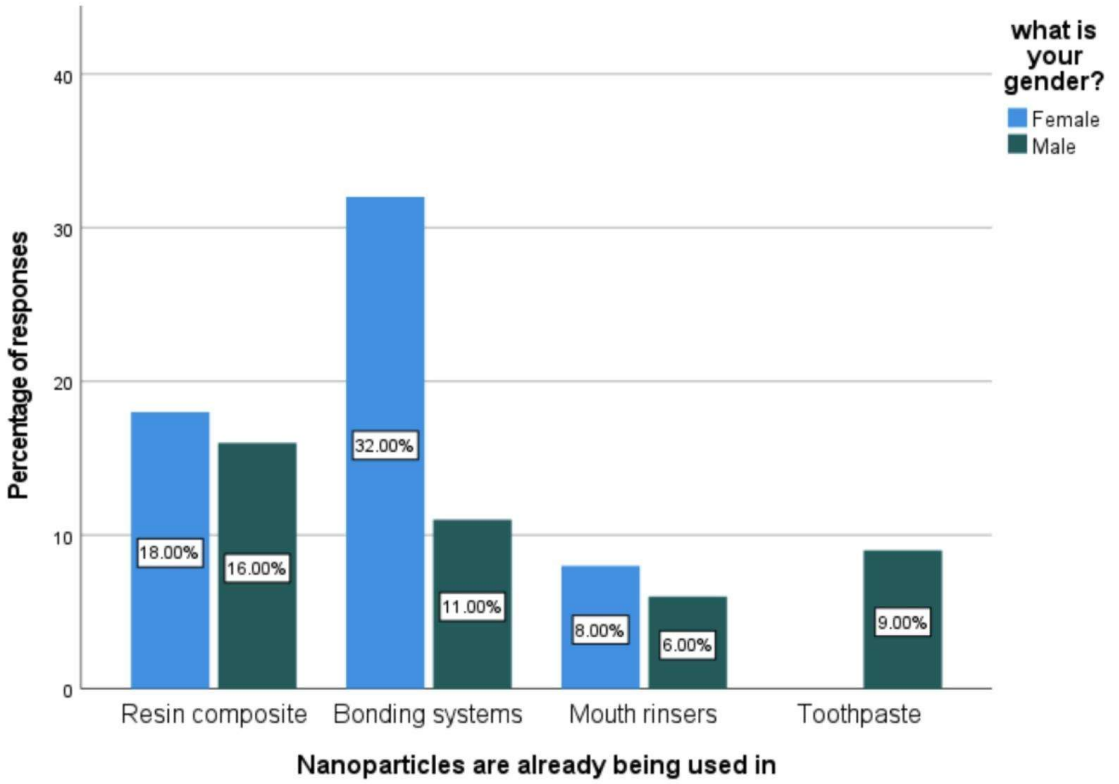

Figure 7: Bar graph depicts the association between gender and the responses of the respondents regarding the use of nanoparticles. X axis represents the materials nanoparticles are already being used in. Y axis represents the percentage of response. Blue colour indicates female and green colour indicates male. Majority of the males (16%) have responded that nanoparticles are already being used in resin composite. Majority of the females (32%) have responded that nanoparticles are already being used in bonding systems. Association between the gender and the awareness of its dental application could not be established (Chi square test, p value =0.06, p> 0.05 insignificant).