Awareness on Nanoparticles Incorporation in Dental Materials among Undergraduate Students - A Cross Sectional Survey

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Authors' contributions

This work was carried out in collaboration among all authors. Author AM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RD and DG managed the analyses of the study. Author RD managed the literature searches. All authors read and approved the final manuscript.

Article Information

Original Research Article

ABSTRACT

Nanotechnology is widely used in day to day life including its use in medicine. Using nanotechnology it is easy to analyse the atoms , chemical bonds and molecules present between various compounds. Use of nanoparticles in the field of dentistry is called nano dentistry. Chemical, physical and biological aspects of nanoparticles should be taken into account while choosing nanoparticles for the use in the field of nano dentistry. Nanoparticles are used in innovations of dentistry. Nano materials can be used for preventing and curing oral diseases such as oral cancer and to maintain oral health care. This study aims at evaluating knowledge and awareness of nanoparticles incorporated in dental materials among undergraduate dental students. A questionnaire with a set of 9 questions to assess the students knowledge and awareness about nanoparticles incorporation in dental materials. The sample size of 99 participants of dental students of Saveetha Dental College were selected by a simple random sampling method. The

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participants were asked to fill the questionnaire in an online site called survey planet. The results were collected and statistically analysed. Chi square test was done and it was found that 71% of the participants were aware about the use of nanoparticles in dental materials, even though it is statistically not significant (p value- 0.436), 73% of respondents were aware about nanoparticle incorporation in impression materials with p value 0.449 (not significant) and 72% were aware about use of nanomaterials in titanium implants(p value-0.340). Within the limitations of the study, it can be observed that the undergraduate students at the Faculty of Dentistry of Saveetha were well aware about the use of nanoparticles in dental materials.

1. INTRODUCTION

The concept of nanotechnology was introduced in 1959 by Richard P Feynman, a Nobel winning physicist, with the fundamental idea of employing machines to make even smaller machine tools until we reach the nano, or atomic level [1]. Nanotechnology can be defined as the science involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale [2,3].

Teeth include various parts like dentin, enamel, cementum, pulp, and periodontal ligament. The function of teeth is to bite, cut and grind the food to make it easy for swallowing and digesting. Tooth also enhances self-confidence and improves the quality of life. Thus the loss of teeth due to disease or decay affects eating patterns, speaking [1]. Thus a lot of importance is given to protect the teeth in the field of dentistry .

Various compounds are used to protect the teeth from decay. Amalgam with good mechanical properties is used. Composite is used to seal crowns and bridge. The sealing was permanently hardened by a polymerization [2].Temporary filling for deciduous teeth is done using Glass Ionomer Cement (GIC). It gives well tolerant capacity and permanently seals crowns and bridges [4].Gold is an ideal material for prosthesis as it is harmless , precision and rigid [5,6].Ceramics are used in fixed prosthetics like crowns and bridges. In removable prosthetics stainless steel is used for framework and clasp [7]. For bleaching, "carbamide peroxide" gels and hydrogen peroxide derivatives are used [8,9]. Although these methods are used in the field of dentistry for many years, they have some disadvantages too.

The main disadvantage of Amalgam which has been used for centuries in dentistry is that it contains mercury which is harmful to our body [10].Composite fillings are highly sensitive towards cold [11]. Ceramics are extremely hard in nature and they can sometimes break. On taking these disadvantages into account nanoparticles are introduced in the field of dentistry [12,13].

Nanotechnology deals with objects of nanometer size and the particles are called nanoparticles (NPs). The most frequently used nanoparticles are silver which is followed by carbon and titanium dioxide (TiO2). The nanoparticle can improve the quality and lifetime of the products by adding many functional groups to it. Thus nano products are widely used in medicine and in the field of dentistry [14].

Nanoparticles are used in Dental implants, dental fillings,Anti Sensitivity agents, prevention of caries, teeth whitening and for teeth surface polishing in the field of dentistry[15]. Hydroxyapatite is a natural nanocomposite of the body, made up of collagen. Hybrid nanomaterials are used to build electronic and memory devices. The dental implant formed of biocompatible materials like hydroxyapatite and titanium embedded into the alveolar bone along with an artificial tooth is available for implantation. This implant, mainly, forms a periodontium and that varies from the structure of the original tissue. A nano toothbrush was invented by incorporating nanogold or nano silver colloidal particles between the bristles. This improves mechanical plaque removal and has antibacterial effects which could untimely lead to a significant reduction in periodontal diseases [16]. Nano calcium fluoride, for was added to mouthwash products to reduce caries activity.The addition of zirconium oxide nanoparticles significantly improves hardness, flexural strength, and fracture toughness of the heat cured PMMAdenture base. Denture base incorporated with TiO2 has increased antibacterial characteristics and mechanical

properties. In addition to this it also has enhanced antimicrobial activity against candida albicans species [17].

In comparison with conventional luting cements, nanoparticles impregnated luting cements are effective in increasing the bond strength between enamel and dentin and also reduces polymerisation shrinkage [18]. The aim of the study was to assess the awareness of nanoparticles incorporation in dental materials among undergraduate students of Saveetha Dental College.

Previously our department has published extensive research on various aspects of prosthetic dentistry [19–29], this vast research experience has inspired us to implement cross sectional surveys on the awareness of nanoparticles incorporation in dental materials among UG students.

2. MATERIALS AND METHODS

The method corresponds to a study survey. The survey was addressed to a number of randomly selected participants of Saveetha Dental College dental students. The questionnaire consisted of a number of questions regarding the incorporation of nanoparticles in dental materials, which were addressed to students in the following years of study: 1st year; 2nd year; 3rd year; 4th year; 5th year. For the realization of the work, statistical analyzes were performed.

The study was done in December 2019 among undergraduate students of Saveetha Dental College on an online setting portal called survey planet. The sample size of 99 participants of dental students of Saveetha Dental College were selected by a simple random sampling method. 9 questions were prepared which included questions to assess the students knowledge and awareness about nanoparticles incorporation in dental materials (Table 1). All participants who filled the questionnaire were informed about the survey. It consisted of two parts: Section 1 demographic data of the participants. In this part, information regarding the year of study was assessed. Section 2: Knowledge and awareness towards nanoparticles incorporation in dental materials was assessed.

The results were collected and tabulated in the MS Excel sheet. Statistical analysis of the data was performed using the SPSS Window Version 20.0 Package program by IBM. Frequency distribution and Chi-square analysis were used to determine if there were any relationships and statistically significant differences between knowledge and awareness about nanoparticles incorporation in dental materials with age and gender. The significance level for the analysis was set at $p \leq 0.05$. The results were statistically analysed and represented in bar graphs.

3. RESULTS AND DISCUSSION

A set of 10 questions were given to 100 undergraduate students of Saveetha Dental college. Questionnaire had two sections: Section 1: Biographic and demographic data of the participants. In this part, information regarding Name, age, gender was assessed.Section 2: Knowledge and awareness towards nanoparticles incorporation in dental materials was assessed. Most of them were aware about the use of nanoparticles in dentistry.

From the statistics it can be well seen that , among 100 students, 71% of them were aware about the incorporation of nanoparticles in dental materials (Fig. 1). The results were lesser when compared to the study by Daoutsali et al., which shows that 75% of the study population were aware and Karen et al., shows 87% were aware about the use of nanoparticles in dental materials. The difference between various studies can be due to differences in sample size and experience of the respondents.

About 60% of students responded to Hydroxyapatite crystals as the natural nanocomposite of the body while 25% responded as silver nanoparticles 14% responded as iron oxide (Fig. 2). According to the study by Ferreira et al., hydroxyapatite nanoparticles have similar composition with teeth and bone making them a biocompatible substance for the physiological process [30]. Nearly 60% of students were aware that silver nanoparticles are the most frequently used nanoparticles in dentistry while 26% said it as Hydroxyapatite and 13% said it as iron oxide (Fig. 3). This study is in accordance with a study by Priyadarsini, silver nanoparticles are most widely used in dental materials and toothpaste (Priyadarsini et al. 2018). According to a study by Ketavat et al.Hydroxyapatite nanoparticles have been used widely in medicine and dentistry [31]. Difference in results among various studies is due to difference in sample size and the study population.

Table 1. Shows the questions, categories, year of study and number of responses in each category, pearson's chi square value and p value

Questions	Choices	Year of study					Pearson chi square value	p value
		1st year	2nd year	3rd year	4th year	5th year		
Are you aware that nanoparticles are used in dental materials?	Yes	4	12	32	12	11	3.786	0.436
	No	3	5	15	1	4		
Which of the following is the natural nanocomposite of the body?	Hydroxyapatite	0	10	29	12	9	17.955	*0.022
	Silver nanoparticles	3	3	5	0	3		
	Iron oxide	4	4	13	1	3		
Which is the most frequently used nanoparticle in dentistry?	Silver nanoparticles	4	3	13	1	5	12.180	0.143
	Hydroxyapatite	1	4	7	0	1		
	Iron oxide	2	10	27	12	9		
Are you aware that nanoparticles are incorporated in impression materials?	Yes	1	5	15	1	4	3.697	0.449
	No	6	12	32	12	11		
Which is the nanoparticle incorporated in titanium implants?	Silver nanoparticles	0	2	7	0	2	24.662	*0.017
	Hydroxyapatite	2	1	0	1	0		
	CuO	3	4	13	0	5		
	FeO	2	10	27	12	8		
Are you aware that addition of nanoparticles in orthodontic adhesives will reduce the occurrence of dental caries?	Yes	4	10	31	12	9	4.913	0.296
	No	3	7	16	1	6		
Which of the following nanoparticles is used in orthodontic adhesives?	CuO	1	10	26	11	9	15.771	0.202
	FeO	2	3	8	1	2		
	Silver nanoparticle	3	4	5	1	2		
	Hydroxyapatite	1	0	8	0	2		
Which is the most important nanoparticle used in endodontic treatment?	Zinc oxide	5	3	19	1	5	16.421	*0.037
	Copper oxide	0	3	2	0	1		
	Silver nanoparticle	2	11	26	12	9		
Are you aware of nanoparticle incorporation in titanium implants?	Yes	1	5	14	1	6	4.522	0.340
	no	6	12	33	12	9		

About 73% of students were aware about the nanoparticles incorporation in impression materials and 26% were unaware (Fig. 4).Nearly

59% of students responded to silver nanoparticles as the nanoparticles incorporated in titanium implants while 25% responded as

Hydroxyapatite, 11% responded as CuO and 4% responded as FeO (Fig. 5). This is in accordance with the study by Rafal et al.,which suggests that titanium implants are incorporated with silver nanoparticles as they are effective against gram positive and gram negative bacteria [32–34]. According to a study by Jonathan et al. titanium implants are incorporated with hydroxyapatite exhibit superior antibacterial activity and better biocompatibility (Rosenbaum et al. 2017). Differences of results between studies may be due to the brand of implant chosen for the study, difference in the sample size.
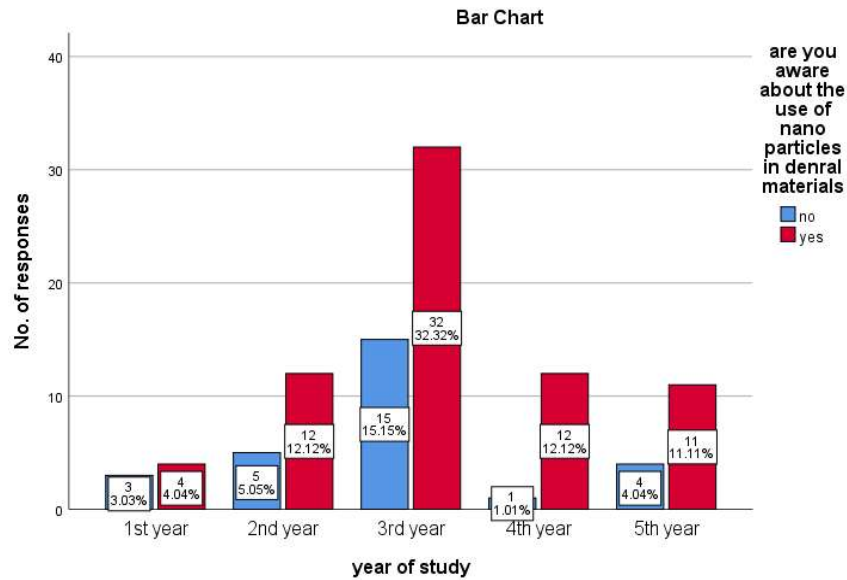
Fig. 1. Bar graph represents the association between year of study and the awareness on use of nanoparticles in dental materials

X axis represents the year of study and Y axis shows the number of responses. 3rd year students have better awareness whereas first years seem to have lesser awareness. Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value :3.786, p value -0.436 (>0.05). Even though it is not significant, higher prevalence of awareness was seen among all groups
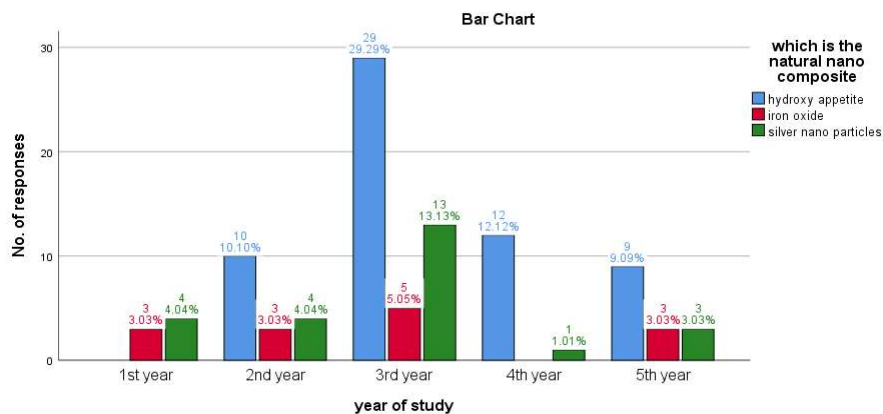

Fig. 2. Bar graph represents the association between year of study and the natural nanocomposite of the body

X axis represents the year of study and Y axis shows the number of responses.Hydroxyapatite has a higher number of responses in all categories. Chi square test was done and association was found to be statistically significant. Pearson's Chi square value :17.955, p value -0.022 (<0.05), shows that hydroxyapatite is the natural nanocomposite of the body
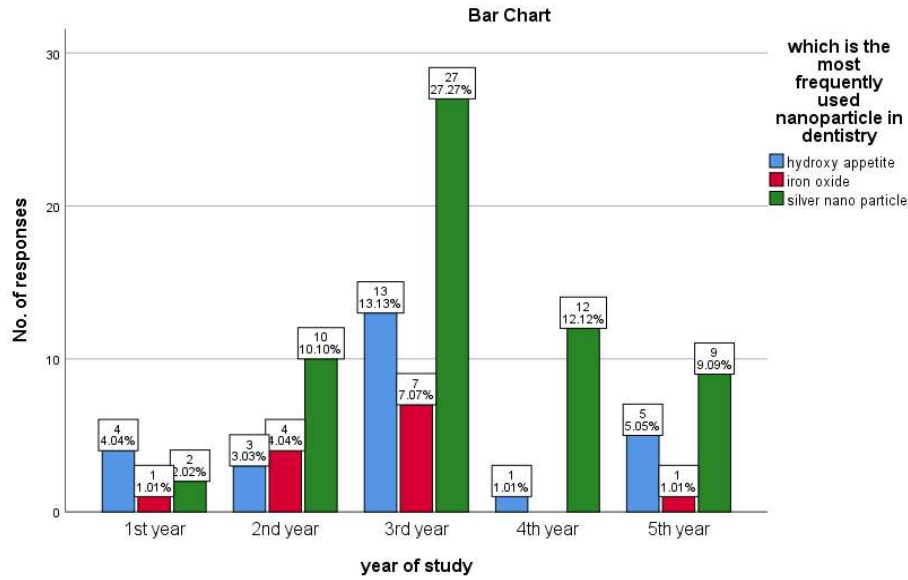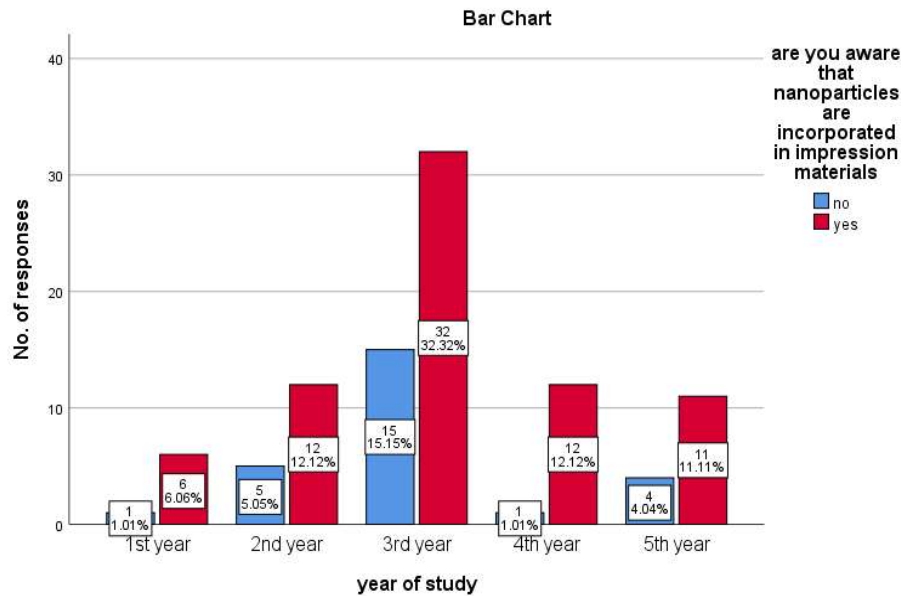
Fig. 3. Bar graph represents the association between year of study and most frequently used nanoparticle in dentistry

X axis represents the year of study and Y axis shows the number of responses. Silver nanoparticles have the higher number of responses among the respondents.Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value :12.180, p value -0.143 (>0.05). Even Though it is not significant it proves that silver nanoparticle is frequently added nanoparticle in dentistry

Fig. 4. Bar graph represents the association between year of study and the awareness on use of nanoparticles incorporated in impression materials

X axis represents the year of study and Y axis shows the number of responses.3rd year students have better awareness than other categories. Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value:3.697, p value -0.449 (>0.05). Even though it is not significant, higher prevalence of awareness was seen among all groups.
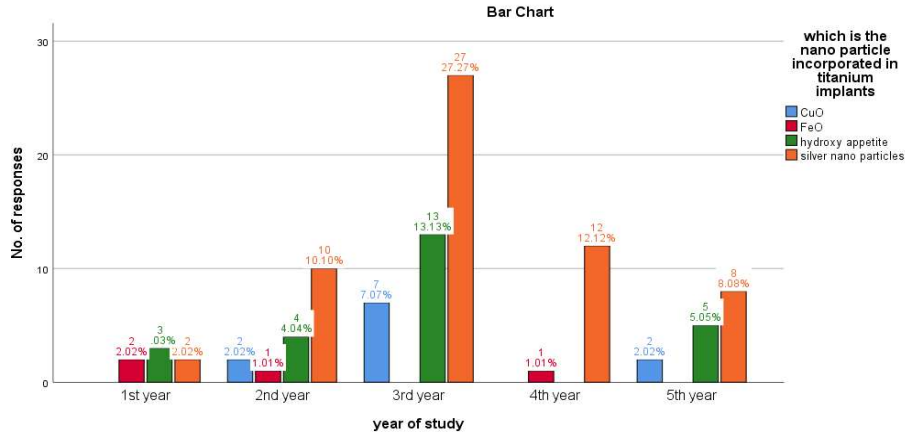
Fig. 5. Bar graph represents the association between the year of study and the nanoparticle incorporated in titanium implants

X axis represents the year of study and Y axis shows the number of responses. Silver nanoparticles have the higher number of responses among the respondents.Chi square test was done and association was found to be statistically significant. Pearson's Chi square value :24.662, p value -0.017 (<0.05), shows that silver nanoparticles is incorporated in titanium implants
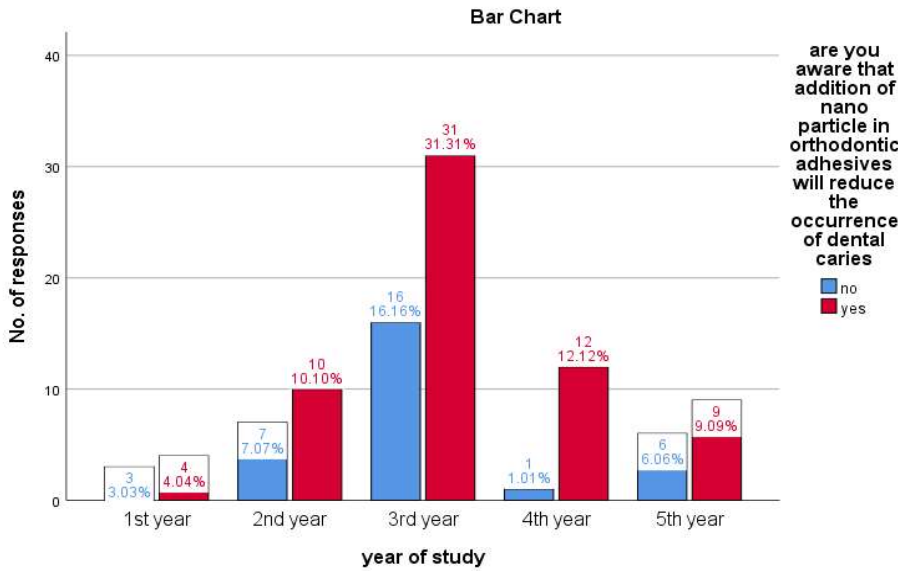

Fig. 6. Bar graph represents the association between year of study and the awareness of nanoparticles incorporation in orthodontic adhesives and its effect on reducing the occurrence of dental caries

X axis represents the year of study and Y axis shows the number of responses.3rd years were more aware than other categories. Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value:4.913, p value -0.296 (>0.05). Even though it is not significant, higher prevalence of awareness was seen among all groups

About 66% of students responded positively that they are aware that the addition of nanoparticles in orthodontic adhesives will reduce the incidence of dental caries and the remaining responded in the negative (Fig. 6). About 57% of students responded CuO as the nanoparticle used in orthodontic adhesives and 16% responded FeO as the nanoparticle used in

orthodontic adhesives (Fig. 7). The results are in accordance with the study by Hossein et al, The addition of CuO nanoparticles promoted the antimicrobial property [35]. On the contrary, the addition of TiO2 nanoparticles presented better antimicrobial activity [36]. Differences in results can be due to difference in sample size or the study population.

60% of students responded to zinc oxide as the nanoparticle used in endodontics and 33% responded to CuO as the nanoparticle

used in endodontics (Fig. 8). According to a study by, incorporation of zinc oxide nanoparticles in calcium hydroxide has enhanced antimicrobial activity [37]. In contrast ,addition of silver nanoparticles exhibit significantly higher antibacterial activity [38]. Differences in results can be due to difference in sample size or the study population. 72% of respondents were aware about nanoparticles incorporation in titanium implants whereas 27% of respondents were unaware (Fig. 9).
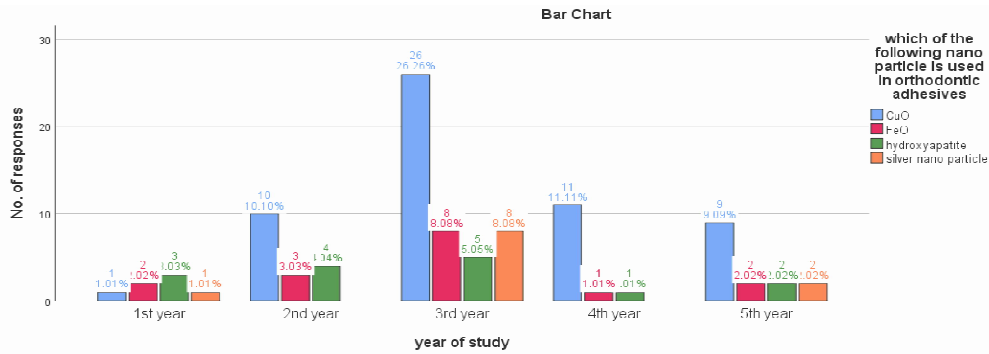

Fig. 7. Bar graph represents the association between the year of study and the nanoparticle used in orthodontic adhesives

X axis represents the year of study and Y axis shows the number of responses. CuO has the higher number of responses among the respondents. Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value :15.771, p value -0.202 (>0.05).Even though it is not significant, it shows CuO as the nanoparticle used in orthodontic adhesives
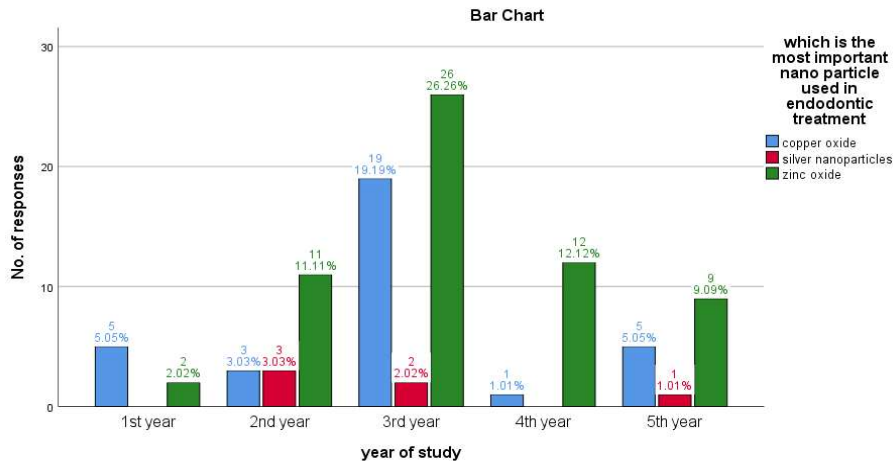

Fig. 8. Bar graph represents the association between the year of study and the nanoparticle used in endodontics

X axis represents the year of study and Y axis shows the number of responses. Zinc oxide has the higher number of responses among the respondents. Chi square test was done and association was found to be statistically significant. Pearson's Chi square value :16.421, p value -0.037 (<0.05), shows that zinc oxide is the nanoparticle used in endodontics
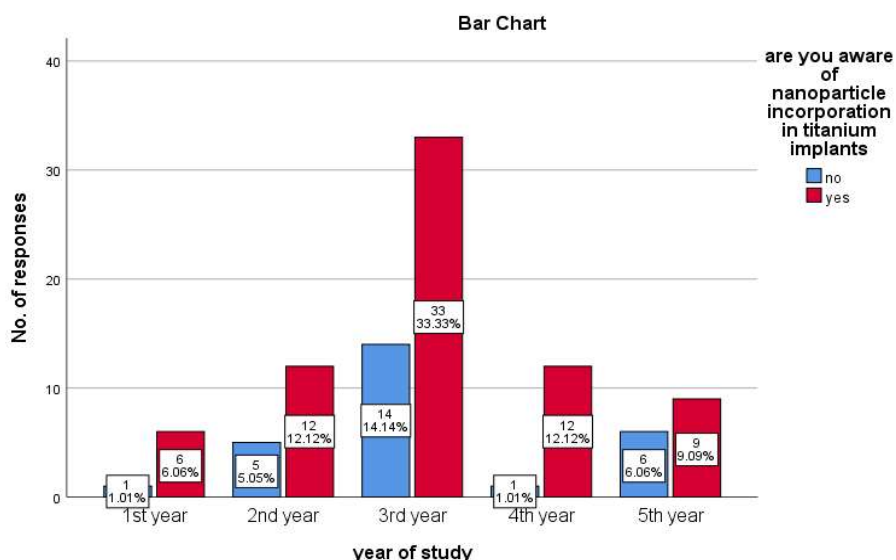
Fig. 9. Bar graph represents the association between year of study and the awareness of nanoparticles incorporation in titanium implants

X axis represents the year of study and Y axis shows the number of responses. 3rd years have better awareness than other categories.Chi square test was done and association was found to be statistically not significant. Pearson's Chi square value:4.522, p value -0.340 (>0.05). Even though it is not significant, higher prevalence of awareness was seen among all groups

Limitations of the study were a smaller population number of respondents . Future scope of the study is to establish in a larger population or particularly to certain speciality or age or experience group among dentists .

4. CONCLUSION

Within the limitations of the study, it was seen that 71% of the participants were aware about the use of nanoparticles in dental materials, even though it is statistically not significant (p value-0.436), 73% of respondents were aware about nanoparticle incorporation in impression materials with p value 0.449 (not significant) and 72% were aware about use of nanomaterials in titanium implants (p value-0.340). The survey results showed that the students are well aware about the use of nanoparticles in dental materials. Nanotechnology is widely used in day to day life including its use in medicine. It can be observed that the undergraduate students were well aware about the use of nanoparticles in dental materials.

CONSENT AND ETHICAL APPROVAL

As per university standard guideline, participant consent and ethical approval have been collected and preserved by the authors

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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