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Survey of the current radiographic practice among general dentists in North Carolina

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Abstract:
Background:*The welfare of patients require adherence to recommended radiologic guidelines. This pilot study assessed the current radiologic practice of general dentists in North Carolina and possible factors that affect these practices.*
Materials and methods*: A cross-sectional study design, using a mixed mode distribution of the survey was used. The survey was sent to a simple random sample of 1500 active community based general dentists in North Carolina. The survey was initially sent electronically twice usingQualtrics followed by a paper survey to the non-respondents.*
Results:*In 72% of the practices multiple personnel performed image acquisition. 74% of the dentists used digital radiography, 87% used round collimation and only 12 % used rectangular collimation. Paralleling technique and XCP was used by majority of respondents. In the last three years majority changed to digital radiography.*
Conclusion: *Respondents who had been in practice the longest and rural respondents tended to use recommended practices less frequently. Years of experience and location of practice influenced use of recommended procedures.*
Practical implications: *Methods to improve the knowledge of radiation safety and dose reduction and implementation of these techniques by general dentists are needed.*
Keywords: *Dental radiography, radiologic practice, survey*

I. Introduction

The American Dental Association (ADA), American Academy of Oral and Maxillofacial Radiology (AAOMR) and North Carolina regulations for protection against radiation (NCAC) recommend dental personnel perform radiographic examinations using optimal radiographic techniques to achieve radiation safety and diagnostic image quality (4,17,24) High quality diagnostic images along with reduced patient dose can be achieved if dental professionals follow the recommendations for standard radiographic practice, which includes well-trained radiographers, shielding, faster image receptors screen/film combinations, proper technique and equipment optimization. ADA guidelines consider the dentist's responsibility to follow the "as low as reasonably achievable principle for radiographic practice (ALARA) prior to making the decision to obtain radiographs (4)

A survey conducted on a random sample of Michigan dentists in 1992 reported that only 5% used recommended rectangular collimation and that most dentists used only D-speed film (15)Platin et al conducted a survey on North Carolina general dentists in 1998 with similar results. Nine percent of general dentists were using E-speed film and rectangular collimation was used by only 7.33% of the dentists (18).Various other surveys conducted in Canada, Turkey, Iran, Greece, Switzerland and Uganda concluded that the standard of radiographic practice is low and ALARA is not followed (2,3,9,14,19,21).

Several studies have indicated that even dental schools are not following the recommendations for radiation protection appropriately. In 1986, a survey of North American Dental Schools concluded that not all dental schools were following the methods available to minimize patient dose (6).In 2002, a survey about radiation dose reduction techniques in North American Dental schools again showed that most of the dental schools did not comply with the ADA recommendations on film speed, collimation and use of a thyroid shield (7). Graduates from schools that use inappropriate practices may not adopt recommended practices in their private practice. Periodic surveys of radiographic practices used in community-based practices are essential to identify deficiencies in radiologic safety practices that could be addressed in continuing education courses and in dental school curricula to appropriately train graduates.

The objectives of this pilot study were to assess the status of current radiologic practices of general dentists in North Carolina and to assess whether years in practice, location of practice or graduation from the

University of North Carolina-Chapel Hill School of Dentistry impacted the choice of intra-oral receptor, collimation method, image acquisition techniques or method of shielding.

II. Materials And Methods

A survey instrument was developed with the assistance of the Odum institute at The University of North Carolina at Chapel Hill to assess current radiographic practices of general dentists in North Carolina. The project was approved by the University of North Carolina Biomedical Institutional Review Board. The questionnaire included 16 questions on the personnel who acquired images, shielding/radiation protection (use of dose monitoring devices, lead aprons, thyroid shields), intra oral image acquisition techniques, equipment used for intra-oral radiography as well as location of practice, years of experience as a private practioner and dental school attended. The location of the practice was self-reported and no population criteria were given. The survey also included an open-ended question asking about any technological changes or modifications that had taken place in the past three years. As a pilot study, eight Operative Dentistry residents at The University of North Carolina School of Dentistry completed the questionnaires and provided feedback on the coherence and structure of the questionnaire.

Email and postal addresses for all 3200 general dentists with an active NC license were obtained from the North Carolina Board of Dental Examiners. A random sample of 1500 practitioners was chosen to receive the survey. A response rate of 35-40% was assumed. With the anticipated response sample size and the nominal scale of measurement of the outcome and explanatory variables of interest, a two-sided Chi-square test would have over 90% power at a 0.05 level of significance to detect a difference of 0.2 in the proportions of an outcome between two groups (for example urban vs rural).

A mixed mode distribution which included an electronic survey followed by a paper survey was used to conduct the survey to lower cost, save time and improve the response rate. A cover letter was emailed to each dentist who had an email address explaining the survey with an invitation to complete the online survey by following the link to the Qualtrics software. A reminder email with the link to the survey was sent out two weeks later to non-respondents. The dentists who did not have an email address and those who did not respond to either email invitation were mailed a cover letter and a copy of the survey created in Teleform (Cardiff Software, Vista, CA) with a postage paid return envelope. All electronic and paper surveys were numerically coded to maintain confidentiality and no personal information was collected on the survey. A linkage file was maintained to avoid any duplicate mailings and was destroyed at the end of the study. Respondents who refused to complete the survey, were not in active practice or were practicing outside North Carolina were excluded from the sample.

Statistical Analysis

The primary outcomes of interest were whether personnel monitoring devices were used; type of receptor used (digital versus film); type of collimation used (rectangular versus round); and type of intraoral technique used (paralleling versus bisecting); and use of receptor holding device (XCP, stabs, snap a ray). Potential explanatory variables included years of experience (<15,15 to < 25, 25 to < 35, >= 35), practice location and origin of dental school (UNC vs not UNC). Bivariate analysis was conducted using chi square statistics (SAS version 9.2). The level of significance for all analysis was set at 0.05.

III. Results

Five hundred seventy three surveys (227 electronic and 346 papers) were returned. Twenty-three were returned due to invalid addresses and 47 surveys were excluded because the practitioner was not in active practice. This yielded a response rate of 40% [n=503] of eligible respondents Seventy-five percent of the respondents worked full time defined as 33 hours per week. Fifty-two percent of the practitioners worked in urban areas and 58% were UNC graduates. (Fig.1).

Multiple personnel performed image acquisition in the majority (72%) of practices. The most frequent combination of personnel was dental assistants and dental hygienists in 29.94% of practices followed by dental assistant (DA), dental hygienist (DH) and dentist in 28.40 % of the practices. Not all personnel who acquired images used monitoring devices. 28% of the dentists performing image acquisition used monitoring devices while 48.6% of the DA and 47.4% of the DH who acquired images used dosimeters. Ninety-three percent of the practices used a thyroid shield and apron but 7% used only a lead apron.

Most of the dentists (74%) reported using digital receptors, 14% used films and about 12% used both. Charge couple device (CCD) was the most commonly used digital receptor followed by Photo-stimulable phosphor (PSP) and complementary metal oxide semiconductor (CMOS) (Fig. 2). Among those practioners who used films, 47% used D speed only and 52% used F speed film and about 2 % reported using both (Fig. 3). Years of experience were statistically significant related to the choice of receptors (P =<0.001). Dentists who had been in practice for 25 to 35 years were more likely to use film (TABLE 1) and were more likely to use D

speed film than F speed film. The choice of the receptor was also significantly related to the location of the practice (p= 0.001). Dentists practicing in urban areas were more likely to use digital receptors (81%) than the dentists practicing in rural areas (67%).

Eighty-seven percent of the practices used round collimation and only 12 % used rectangular collimation. Neither length in practice, practice location, nor school of graduation was statistically significantly related to the choice of collimation (TABLE 2). Paralleling technique was used by 33% of the practices and bisecting by five percent. Fifty-five percent used both paralleling and bisecting and six percent did not know the technique used. Type of technique used was affected by the years of experience ($p<0.001$) and school of graduation. Dentists in practice for 15 to less than 35 years reported both paralleling and bisecting techniques. Dentists who had been in practice for 35 years or more were more likely to use only paralleling technique. Non-UNC graduates more frequently reported using "both" techniques while UNC graduates more frequently reported using "other". A substantially higher percentage of those who had been in practice for less than 15 years reported using an "other" technique for image acquisition. The location of the practice ($p = 0.9$) was not related to the choice of technique while the school of graduation ($P= 0.05$) was statistically significant (TABLE 3).

The majority of practices used XCPs (TABLE 4) followed by more than one and stabes. Location ($p=0.0001$) and years of experience ($p=0.02$) were significantly associated with the choice of receptor holding device. Urban practices and dentists with less than 15 years of experience were more likely to use XCP.

About 38% of the practioners reported they made changes/ modifications in their radiologic practice in the past three years, primarily reporting conversion to digital radiography. Of the ALARA recommendations addressed in this survey, only four percent of the practices reported following all and 95% followed some of the guidelines.

IV. Discussion

Implementation of recommended radiation practices in community-based practices is vital for the safety of practitioners and patients. The American Dental Association and the American Academy of Oral and Maxillofacial Radiology recommend the use of the fastest image receptors which include F speed film and digital receptors, beam limitation best achieved by rectangular collimation, use of personnel dosimeters and use of lead aprons and thyroid shields when possible (4, 24).

The recommended use of shielding according to both ADA and NCAC includes thyroid shields and leaded aprons unless they interfere with diagnostic procedures. However, if all recommendations are followed for reducing radiation exposure, abdominal shielding is not considered necessary (4,17). Support for the use of the thyroid shields is less clear. Sikroski and Taylor in 1984 supported the use of thyroid shields while Roth in 2006 concluded that during dental x-ray examinations thyroid shields were not helpful for protecting the patient from unnecessary radiation exposure (10, 20).A recent study about intra-oral imaging risk reduction with collimation and thyroid shielding reported that round collimation with thyroid shield causes less dose reduction than rectangular collimation alone. In other words it implied that the thyroid shield is not required if rectangular collimation is used (11). The use of personal dosimeters to monitor exposure levels is recommended for employees who acquire radiographs (17). The ADA recommends dosimeters for employees who may receive an annual dose greater than 1 mSv. Pregnant employees acquiring radiographs should use them no matter how minimal the exposure level is (4). Not all personnel who were identified as acquiring images in this study reported using monitoring devices. Only 28% of dentists performing image acquisition used personal dosimeters. Forty-nine percent of dental assistants and 47.4% of dental hygienists acquiring images used dosimeters.

The use of F speed film compared to D speed film can reduce radiation exposure by about 60 percent without altering diagnostic quality (22,23). Radiation exposures can be further decreased significantly by using digital sensors or F-speed film in combination with rectangular collimation (4,5,12,17,21,24). Almost three quarters of respondents in this study used digital receptors. Dentists practicing in urban areas were more likely to use digital receptors (81%) than those practicing in rural areas. Dentists in practice the longest tended to use D speed film. In 1998, only 9% of NC general practice was using E-speed film and about 90% were using D speed film (18). Compared to 1998 use of films has diminished drastically. Most dentists are using digital radiography, 14% reported use of films exclusively. Among those D speed film only was used by 36% and F speed film was used by 53% and nine percent reported use of both D and F speed film.

Rectangular collimation decreases the radiation dose significantly as compared with a circular collimation. Dentists can decrease the patient exposure by a factor of ten for bitewing and full mouth series by using digital sensors or F-speed film, combined with rectangular collimation (11,13,16).Surprisingly 87% of the practices currently reported using round collimation while only 12 % used the recommended rectangular collimation. However, it is important to note that some dentists may consider use of a circular collimator and

receptor holding device that collimates the beam to the shape of the receptor. (i.e. Precision Instrument, JadRad, etc.).

On one hand, this survey showed that dentists are accepting new technology by switching to digital radiography but on the other hand there are some core deficits in radiologic practice. This survey implies that senior dentists are reluctant to change. It could either be due to their inhibitions about the learning curve or unawareness due to lack of their continuing education. This also applies to the rural dentists. The explanation for them still using films could possibly be contemplation of making large investments compared to their revenues. However their non-compliance with radiation safety recommendations may again be due to lack of continuing education.

It was interesting to note that almost one-third of respondents were unaware of the type of digital receptors they used in their practice. This could either imply the dentists didn't answer the questionnaire themselves or were carried away by a smooth talking sales representative and just blindly accepted the offer.

There are limitations of this study that should be considered in the interpretation of the data. First, the response rate was only 40% although the response rate of this study is in line with other studies surveying a general dentist population. Second the location of the practice was self-reported by the dentists and had no set criteria for categorizing it as rural or urban. Third there is no certainty that all the questionnaires were completed by the dentists themselves given that some respondents responded "none" or "don't know" for questions that they could reasonably be expected to know the answer. For example, six percent of the respondents didn't know the type of technique they used to acquire images and about 30% of dentists who used digital radiography did not know the type of receptor they used. It is unlikely that a dentist would be unaware of the type of technique used to acquire images. Fourth, the survey was designed to obtain overall practices for exposing radiographs. Specific questions related to pregnant women or children were not included and may have provided useful information. Fifth, dentists were questioned about lead aprons and cervical collars but not specifically for intra oral radiography or panoramic radiographs. The type of projection being exposed would have influenced the need for lead aprons and cervical/thyroid collars. Last, selection criteria and quality assurance protocols, which are important factors contributing to reduction in radiation exposure, were not in the parameters of this study.

V. Conclusion

This survey indicated that most dentists in the state of North Carolina reported using digital receptors and the use of D speed film has drastically declined. This was good news since the use of faster image receptors results in lower exposures to patients. However, the use of circular collimation remains high. Encouraging practitioners through education to use rectangular collimation will result in further exposure reduction to patients and improve image quality. Rectangular collimation reduces the scatter and secondary radiation exposure there by reducing fogging and improving contrast (8). The survey also showed that the preponderance of respondents complied with the NC regulations for shielding patients during dental radiography examinations. Years of experience and location of practice influenced the use of recommended practices. Respondents who had been in practice the longest and rural respondents tended to use recommended practices less frequently. Dissemination methods to improve the general dentist's knowledge of radiation safety and dose reduction and encourage the implementation of these techniques are needed (1). Additional studies are recommended to include the use of Panoramic and CBCT imaging methods. In addition collection of information should be considered through collaborative agreements with Radiation regulatory agencies.

This survey is a pilot study, which will help in laying a foundation for national survey. The challenges and limitations were encountered in this study will help us to further conduct an improvised survey on a larger scale to identify discrepancies in our dental radiographic practice.

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Figures And Tables

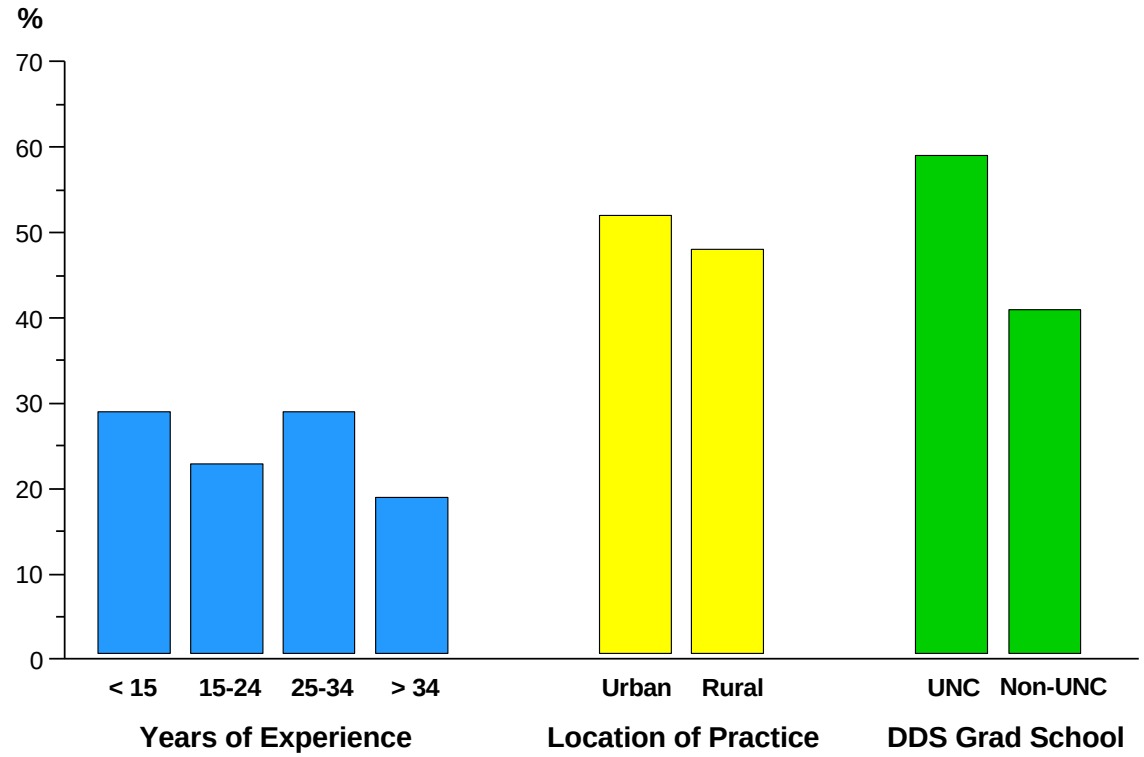

Figure 1: over all distribution of the dentists according to years of experience, location of practice and graduate school attended

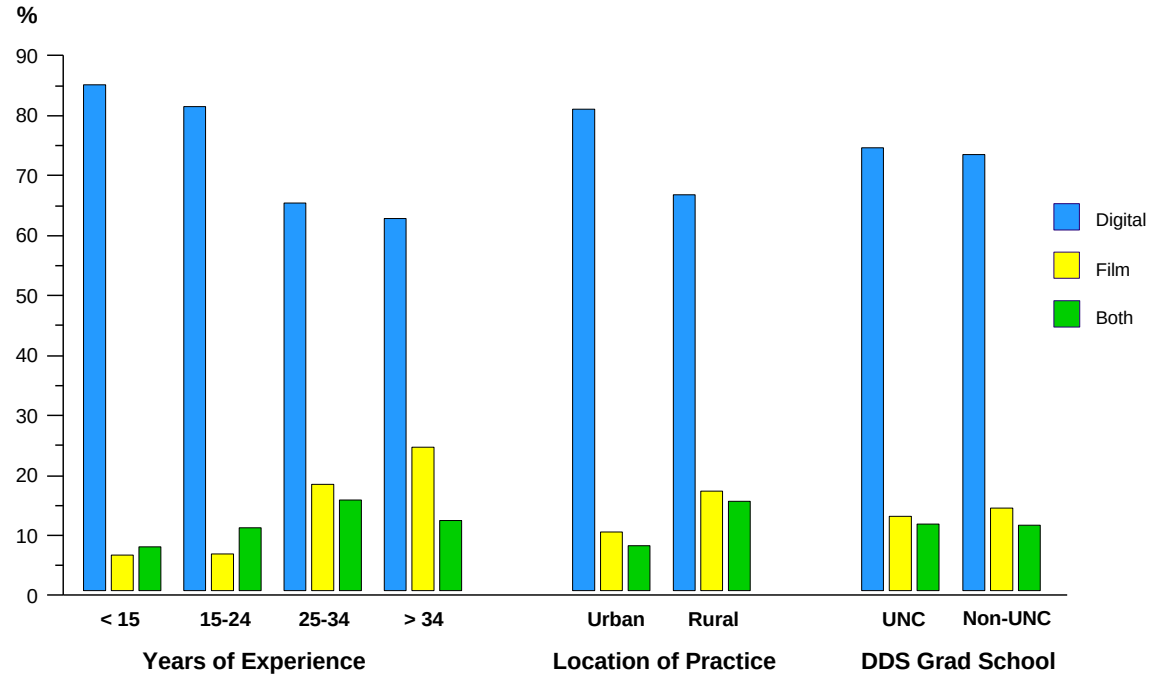

Figure 2: receptor choice based on years of experience, location of practice and graduate school attended.

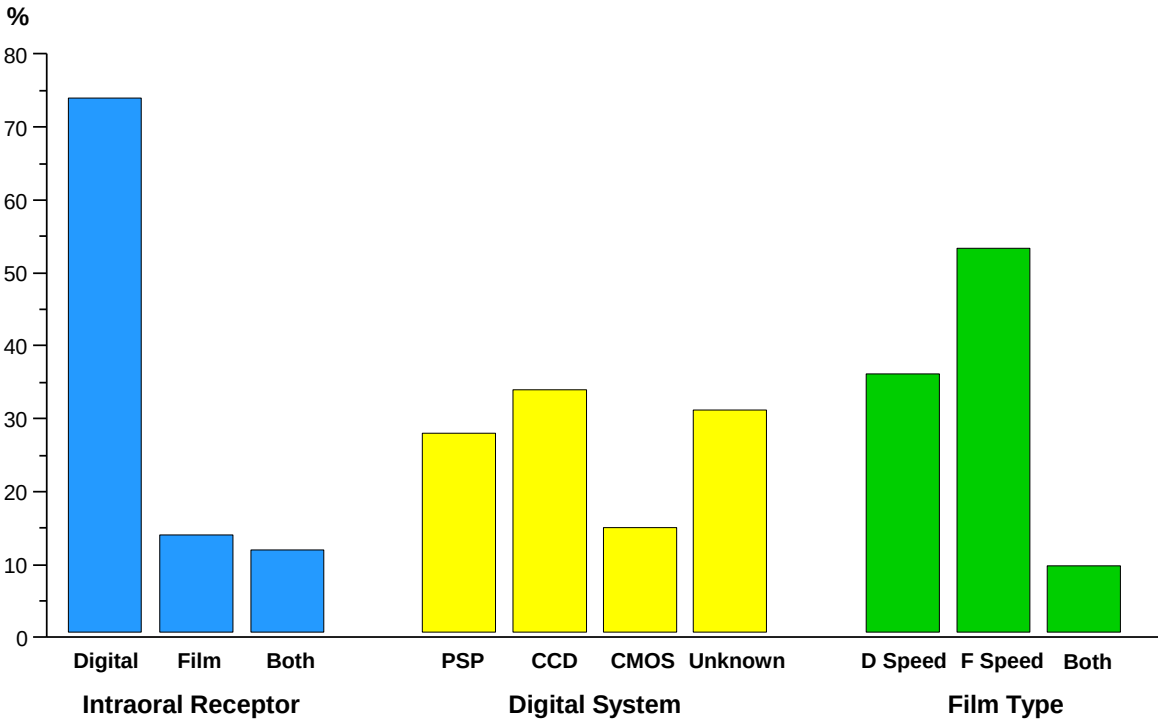

Figure 3: Percentage of practioners using digital and film radiography.

Table 1: Percentage of practices using digital radiography and film and their association with years of experience, location of practice and graduate school attended DDS Grad School.

Use of Receptor	Digital		Film		Both		
Years of experience	n	%	n	%	n	%	P value
<15	126	85.14	10	6.76	12	8.11	<0.0001
15 to < 25	93	81.58	8	7.02	13	11.40	
25 to < 35	95	65.52	27	18.62	23	15.86	
>= 35	61	62.89	24	24.74	12	12.37	
Location							
Urban	215	81.13	28	10.57	22	8.30	0.001
Rural	161	66.80	42	17.43	38	15.77	
DDS Grad school							
UNC	219	74.74	39	13.31	35	11.95	.91
Non-UNC	156	73.58	31	14.62	25	11.79	

Table 2: Percentage of the types of collimation used and their association with years of experience, location of practice and graduate school attended.

Type of collimation	Rectangular		Round		Other		
Years of experience	n	%	n	%	n	%	P value
<15	22	15.49	120	84.51	0	0.00	.23
15 to < 25	8	7.02	104	91.23	2	1.75	
25 to < 35	16	12.03	115	86.47	2	1.50	
>=35	11	11.58	84	88.42	0	0.00	
Location							
Urban	27	10.55	228	89.06	1	0.39	.36
Rural	30	13.04	197	85.65	3	1.30	
DDS Grad school							
UNC	33	11.79	244	87.14	3	1.07	.78
Non-UNC	24	11.71	180	87.80	1	0.49	

Table 3: Percentage of the types of image acquisition technique used and their association with years of experience, location of practice and graduate school attended.

Technique used	Parallel		Bisecting		Both		Other		P value
Years of experience	n	%	n	%	n	%	n	%	
<15	51	34.93	9	6.16	63	43.15	23	15.75	<.0001
15 to < 25	29	25.22	5	4.35	77	66.96	4	3.48	
25 to < 35	50	34.25	9	6.16	84	57.53	3	2.05	
>=35	36	36.73	4	4.08	57	58.16	1	1.02	
Location									
Urban	90	34.09	15	5.68	143	54.17	16	6.06	

Rural	**77**	**31.69**	**12**	**4.94**	**138**	**56.79**	**16**	**6.58**	**0.90**
DDS Grad school									
UNC	**98**	**33.11**	**15**	**5.07**	**15**	**53.04**	**26**	**8.78**	**.05**
Non-UNC	**69**	**32.86**	**12**	**5.71**	**123**	**58.57**	**6**	**2.86**	

Table 4: Percentage of the receptor holding devices used and their association with years of experience, location of practice and graduate school attended.

Use of Receptor holding device	**XCP**		**Stabes**		**Snap a ray**		**More than 0ne**		**Other/None**		
Years of experience	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**P value**
<15	**89**	**62.24**	**7**	**4.90**	**2**	**1.40**	**42**	**29.37**	**3**	**2.10**	**0.0001**
15 to <25	**61**	**55.45**	**9**	**8.18**	**1**	**0.91**	**32**	**29.09**	**7**	**6.36**	
25 to <35	**52**	**37.96**	**22**	**16.06**	**7**	**5.11**	**54**	**39.42**	**2**	**1.46**	
>= 35	**34**	**40.48**	**14**	**16.67**	**2**	**2.38**	**27**	**32.14**	**7**	**8.33**	
Location											
Urban	**140**	**54.90**	**18**	**7.06**	**6**	**2.35**	**80**	**31.37**	**11**	**4.31**	**0.02**
Rural	**96**	**43.64**	**34**	**15.45**	**6**	**2.73**	**76**	**34.55**	**8**	**3.64**	
DDS Grad school											
UNC	**129**	**46.74**	**35**	**12.68**	**6**	**2.17**	**93**	**33.70**	**13**	**4.71**	**.39**
Non-UNC	**106**	**53.54**	**17**	**8.59**	**6**	**3.03**	**63**	**31.82**	**6**	**3.03**	