Cone Beam Computed Tomography Interpretation in Orthodontic Practices

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Cone Beam Computed Tomography Interpretation in Orthodontic Practices

Accurate visualization of skeletal and dental relationships is important for proper diagnosis and effective treatment planning. For decades, orthodontists have relied upon plaster models, photographs, and 2-dimensional radiographs to diagnose skeletal and dental discrepancies. As technology has improved, new methods have become readily available to help orthodontists visualize the craniofacial complex more efficiently.[i]

Cone beam computed tomography (CBCT) is one such technology. It utilizes a rotating framework with a fixed detector on one end and the x-ray source on the other, creating a cone shaped source of ionizing radiation that penetrates an object. As the machine rotates, multiple planar images are captured and stacked to create 3-dimensional images.[ii] CBCT combines traditional digital x-ray and computer volumetric reconstructions to make accurate 3-dimensional images that can be analyzed from multiple angles in space.[iii]

CBCT first appeared in the dental field in 1998 and has since garnered tremendous support and widespread usage from various specialties because it offers distinct advantages over traditional imaging techniques.[iv] CBCT measurements are accurate to a subvoxel size. This allows the provider to observe the cranial base, dentofacial complex, soft tissue, and airway in a one to one ratio.[v] The 3-dimensional image also allows visualization of the patient's underlying bony architecture in the sagittal, coronal, and axial planes leading to the precise location of impacted, ectopic, or supernumerary teeth. In addition, the accurate 3-dimensional representation without distortion from other anatomic structures aids in the visualization of craniofacial anomalies.[vi,vii]

While these advantages are appealing, the American Academy of Oral and Maxillofacial Radiology (AAOMR) indicates no distinct benefit has been demonstrated for patients with dental crowding and that despite the many publications on CBCT use in orthodontics, most are observational studies with varying degrees of procedural soundness.[viii] They caution that a CBCT record should not be considered on every patient because there are characteristics unique to CBCT that can pose challenges. These challenges include increased radiation exposure to patients and difficulty interpreting the large amount of data contained in the 3-dimensional image. The challenges are magnified when a large field of view (FOV) CBCT is taken that captures the entire craniofacial complex because many incidental findings are extragnathic, or outside the area of expertise of most orthodontists. As a consequence, it is important that a comprehensive review for each patient's CBCT image be conducted and documented.[ix]

The purpose of this study was to determine current trends in CBCT interpretation methods and identify factors that influenced a provider's decision to complete comprehensive CBCT interpretations themself versus referring to a third party such as a maxillofacial radiologist. Additional goals of the study were to provide a current assessment of how many providers are using CBCT technology in their practice, when CBCT imaging is typically prescribed, and which CBCT FOV providers felt most comfortable interpreting on their own.

Materials and Methods

The 59th Medical Wing Institutional Review Board granted approval for this study. An online questionnaire hosted by SurveyMonkey.com was submitted to the American Association of Orthodontists (AAO) Survey Review Committee of the AAO Board of Trustees. Upon approval, the AAO's Partners in Research Program randomly distributed the survey via email to a group of approximately 2100 orthodontists. Participation in the survey was voluntary and in an effort to increase the number of participants, a second email was sent out two weeks after the initial email.

The survey consisted of 19 questions regarding the use of CBCT technology in orthodontic practices. Questions were designed to gather information on when providers take a CBCT record, the most common CBCT FOV prescribed, and if a third party is used to comprehensively interpret the CBCT image. Each question was presented in multiple-choice format. One question had a "select all that apply" option whereas the remainder required only one answer. The data was exported from SurveyMonkey.com into Excel. Data analysis was accomplished using Statistical Package for the Social Sciences (SPSS) software.

Results

150 responses were ultimately collected representing a 7.1% response rate. Due to the limited sample size, statistical significance could not be achieved with traditional

chi-square analyses. However, the raw data collected from the study provided adequate information to identify current trends in CBCT interpretation preferences as well as insight into possible future trends in CBCT interpretation. The majority of respondents (64%) indicated they owned a private practice where they were the only orthodontist. The remainder of respondents included private practices with more than one owner or provider (22%), group practices with additional dental specialties (9%), corporate offices (3.5%) and military providers (1.5%).

More than half (54%) of the respondents indicated they currently use CBCT technology in their practice. Figure 1 shows the different circumstances in which providers prescribed a CBCT record. The most common circumstances included visualization of impacted or supernumerary teeth (73%) and suspected pathology (60%). Providers were also asked to identify the CBCT size or FOV they most often prescribed when diagnosing cases. Large FOV included the entire craniofacial complex, medium FOV included upper and lower jaws only, and small FOV included a single quadrant or tooth. Respondents indicated that large FOVs were most commonly prescribed (47%), followed by medium (39%), and then small (14%).

Figure 3 is a flow diagram illustrating the overall interpretation preferences for each CBCT FOV. Providers were most likely to utilize a third party to interpret large FOVs (48%), followed by medium (26%) and small (23%). When referring, the most commonly used specialist to interpret the CBCT was a maxillofacial radiologist with 76% of providers indicating them as their specialist of choice over oral surgeons (10%) and medical radiologists (8.5%).

Figure 4 shows the different CBCT FOVs providers felt most confident interpreting without referring to a third party. No statistical significance or specific trend was identified in this comparison as 24% of respondents indicated they were confident interpreting small FOVs, 28% said they were confident interpreting medium, and 29% were confident interpreting large. The remaining 19% said they always referred to a third party for interpretation no matter the CBCT FOV.

In regard to CBCT training, the majority (59%) of CBCT users indicated their state does not require additional CBCT certification to interpret images. Of the remaining, 37% said they were unsure and only 4% said additional certification was required. While CBCT certification did not appear to be required in many states, 58% of the CBCT users said they had taken a course in CBCT interpretation. When comparing the presence of additional CBCT education with interpretation preferences, respondents who had additional CBCT training were more likely to refer to a third party for all CBCT FOVs. Figure 5 is a comparison demonstrating this trend. In the small FOV grouping, 25% of respondents who had taken a CBCT course referred for interpretation whereas only 17% of respondents who had not taken a course chose to refer. In the medium FOV grouping, referral percentages increased for both groups. Those who had additional training still referred more than those who did not, 28% compared to 23% respectively. This trend continued in the large FOV group with 53% of the CBCT trained group referring compared to 40% of the non-trained group.

Another comparison of importance to the study was provider practice type and CBCT interpretation preferences. Figure 6 is a diagram comparing the interpretation preferences for each CBCT FOV and the 5 different practice types identified in the study (private practice with a single owner, partnerships with more than one provider/owner, group practices with more than one specialty, corporate practices, and military practices). As CBCT FOV increased from small to large, the percentage of interpretation referrals increased in all practice types except military practices. Military practices were most likely to refer, and referred 100% of the time for each FOV. Corporate owned practices had the second highest referral percentages (small FOV: 67%, med FOV: 67%, large FOV 100%). Group practices with more than one dental specialty had the third highest referral percentages (small FOV: 40%, med FOV: 50%, large FOV 56%). Private practices with one owner/provider had the fourth highest referral percentages (small FOV: 23%, med FOV: 25%, large FOV 53%). Finally, partnerships with more than one owner had the lowest percentage of referrals for all CBCT sizes (small FOV: 0%, med FOV: 0%, large FOV 14%).

In regard to the 46% of respondents who do not currently use CBCT imaging in their practices, less than half (30%) said they plan on using CBCT in the future. Of these, the majority (65%) said they would primarily prescribe medium FOV CBCT images. The remaining 35% said they would primarily prescribe large FOV CBCT images. Figure 7 is a diagram demonstrating the interpretation method most likely used for each CBCT FOV in the future. As the CBCT FOV increased, the percentage of providers favoring third party interpretations also increased as 28% of providers said they would refer for small FOV interpretations, 50% said they will refer for medium FOV interpretations, and 75% said they would refer for large FOV interpretations.

Discussion

Correct diagnosis leads to treatment success and CBCT can enhance the orthodontist's ability to diagnose dentofacial discrepancies in three planes of space.[x] While there is concern that 3-dimensional imaging increases radiation exposure to patients, newer protocols and the ability to diagnose with lower resolution CBCT images have resulted in only a small increase in radiation when compared to conventional panoramic and cephalometric radiography. As a consequence, CBCT is beginning to replace traditional 2-dimensional radiography in orthodontic practices.[xi,xii] This trend was supported by the study with more than half of the respondents currently prescribing CBCT in their practices. The study also supported previous studies in identifying the most frequent indication of CBCT in orthodontics to be cases involving retained or impacted permanent teeth and severe cranial facial anomalies.[xiii] It appears that CBCT is becoming the standard of care for more complex cases because of its ability to visualize the craniofacial complex in three planes of space.

The scope of CBCT in orthodontics appears to be increasing beyond traditional orthodontics as well. A recent indication of this was on display at the 2019 AAO Winter Conference. The role of the orthodontist in treating sleep disorders was the major theme and many feel it will be a significant part of the orthodontic profession moving forward. The benefits of using CBCT to measure the upper airway in three dimensions was discussed in detail and as more importance is placed on the orthodontist's role in screening and treating patients with sleep disorders, large FOV CBCT images may become even more popular.

As CBCT becomes more popular however, accurate interpretation of these images remains an issue and can pose challenges to the orthodontist attempting to perform interpretations alone. A study conducted by Smith et al. in 2011 indicated that nearly 60% of the orthodontic residency programs using CBCT had interpretations completed by radiologists while only 32% held residents responsible for interpreting

CBCTs and referring abnormal findings.[xiv] Another study by Ahmed et al. tested the ability of orthodontists and orthodontic residents to identify maxillofacial lesions on a CBCT. Only 41% of lesions were discovered before participants were trained in CBCT interpretation. The number increased modestly to 57% after training.[xv] This is cause for concern because non-odontogenic incidental findings are common, often manifesting in the airway and paranasal sinuses, and nearly 50% of orthodontists will discover pathology in a patient during their career at sites outside of the dental complex.[xvi,9]

With such observations, it is reasonable to believe that as the FOV increases to include extragnathic anatomy outside the area of expertise of the orthodontist, referring CBCT interpretations to qualified specialists such as a maxillofacial radiologist would be more likely. This trend was supported by the study and as CBCT FOV increased from small to large, interpretation referral rates increased as well. Furthermore, it would seem logical for legal and ethical purposes that referring CBCT interpretations would be preferred due to the amount of data contained in the image and the probability of incidental findings. Perhaps the most intriguing observation in the study was the interpretation preferences of providers who indicated they had additional training in CBCT interpretation. After receiving training in CBCT interpretation, one might expect these providers to be more confident in their ability to interpret images and less likely to refer when compared to those who had no CBCT training. This was not observed in the study, and providers with additional training were actually more likely to refer. A possible explanation for this trend was postulated to include the following logic. With additional CBCT training, providers may be more aware of the large amount of data and anatomical variation contained in a CBCT image that must be included in an acceptable comprehensive interpretation. With this additional knowledge, providers may have realized their limitations as clinicians. Due to the additional challenges of CBCT interpretation with possible legal consequences of misdiagnosis, referring interpretations to a specialist may be most prudent choice to maximize clinical efficiency and satisfy both legal and ethical considerations.

Conclusion

In conclusion, the small sample size of 150 providers led to challenges in establishing statistical significance using traditional chi-squared analyses, therefore only the raw data was analyzed and presented in the study. There was also the chance of selection bias because providers currently using CBCT may have been more inclined to respond than those not using CBCT. Despite these limitations, the study did provide an intriguing insight into current CBCT trends amongst the orthodontists that responded. While the majority of study participants interpret CBCT images themselves for all FOVs, they were more likely to refer interpretations as the CBCT FOV increased. Those with CBCT training were more likely to refer than those with no CBCT training, and military providers were more likely to refer for all FOVs while partnerships were least likely to refer. Additional studies would be beneficial to further solidify these trends and obtain more information on CBCT interpretation preferences. Ultimately, when making the decision to use CBCT, the orthodontist should put the health of the patient first. Most dental clinicians would agree that if a panoramic radiograph showed a lesion or an impacted tooth, it would be the clinician's responsibility to disclose the findings to the patient. Perhaps it was Turnpin who posed the two most important questions to consider when deciding who should interpret a CBCT.

> "Is it the orthodontist's responsibility to explain the full depth of the information that is encapsulated in this 3-dimensional image? For that matter, will most orthodontists fully understand what those images have to say?"[xvii]

The views expressed are those of the [author(s)] and do not reflect the official views or policy of the Department of Defense or its Components.
The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DODI 3216.02_AFI40-402.

Figure Captions

Fig 1 Indications for prescribing a CBCT image

Fig2 CBCT FOV primarily prescribed by providers

Fig 3 CBCT FOV and interpretation referral preferences

Fig 4 FOVs providers felt confident interpreting without referral

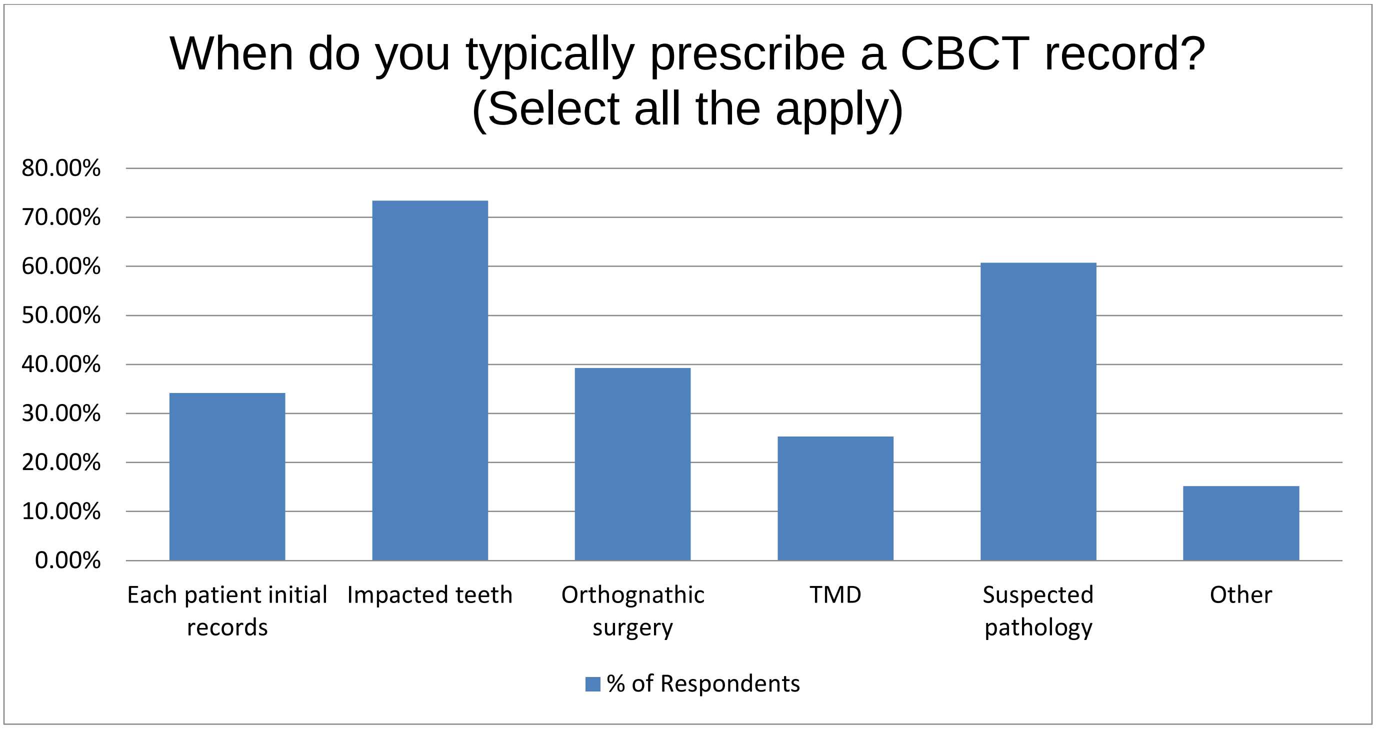
Fig 5 CBCT interpretation training and referral preferences

Fig 6 Practice type and CBCT interpretation referral preferences

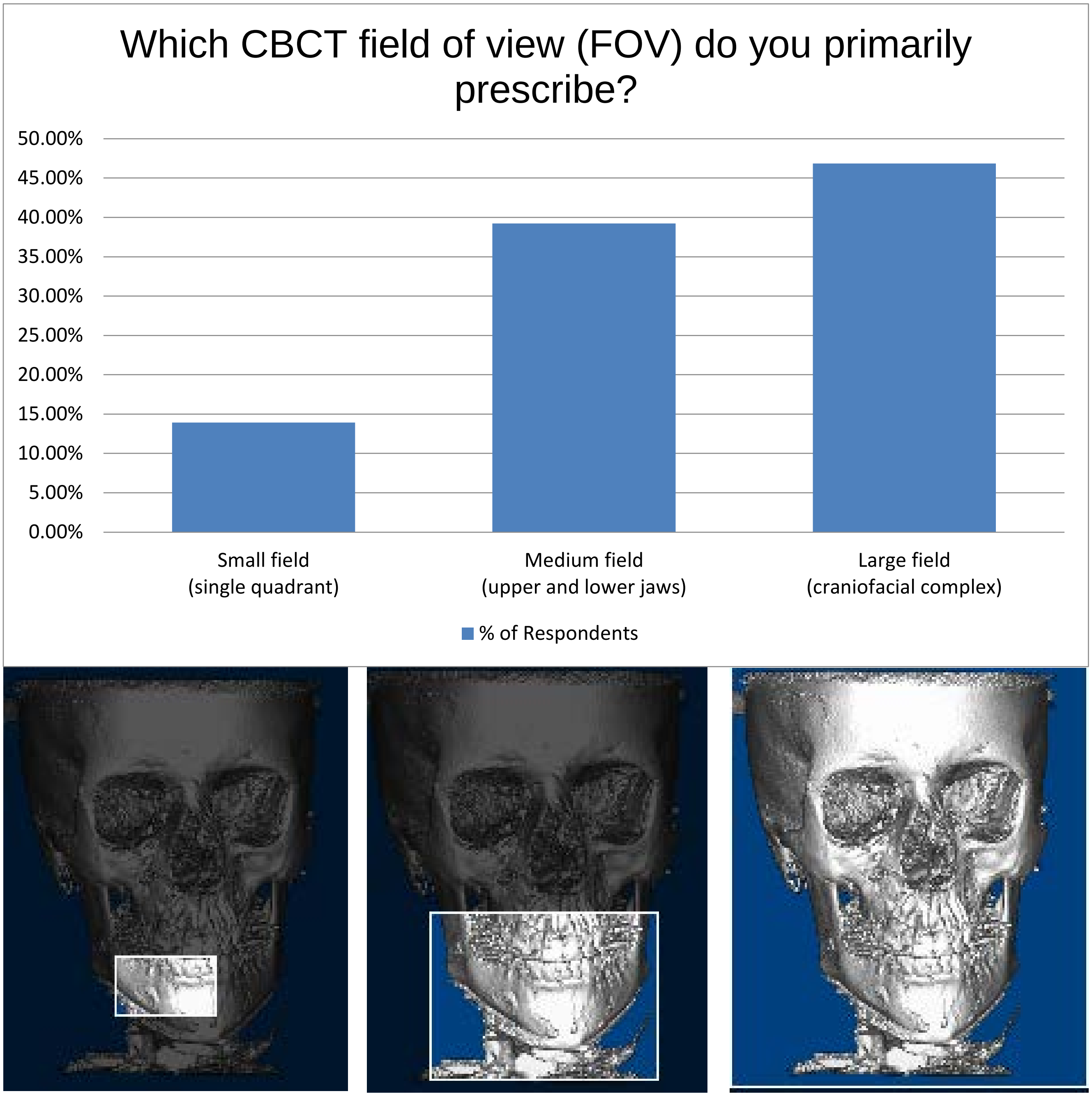
Fig 7 Provider projections on future CBCT referral preferences

Figures

1.

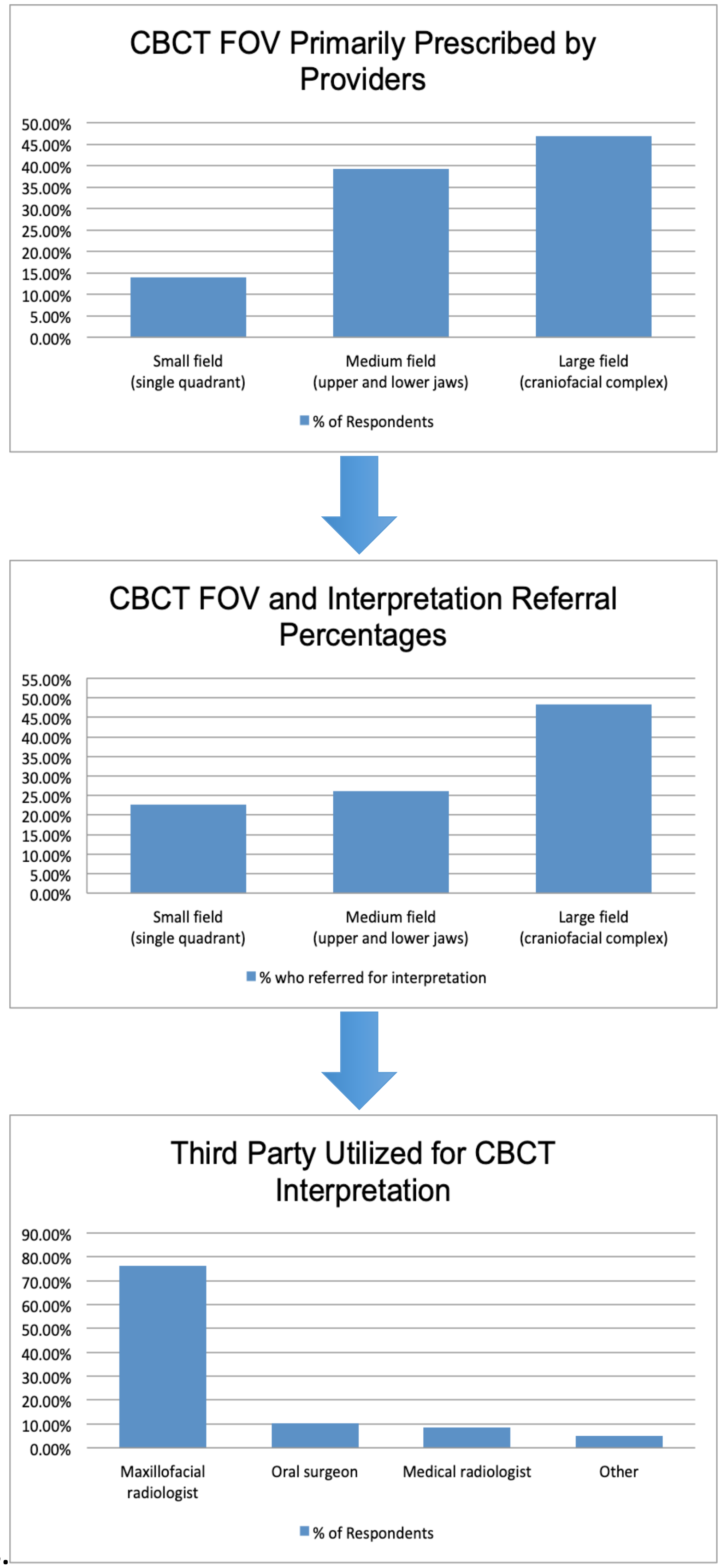

When do you typically prescribe a CBCT record? (Select all the apply)
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Each patient initial records
Impacted teeth
Orthognathic surgery
TMD
Suspected pathology
Other
% of Respondents

2.

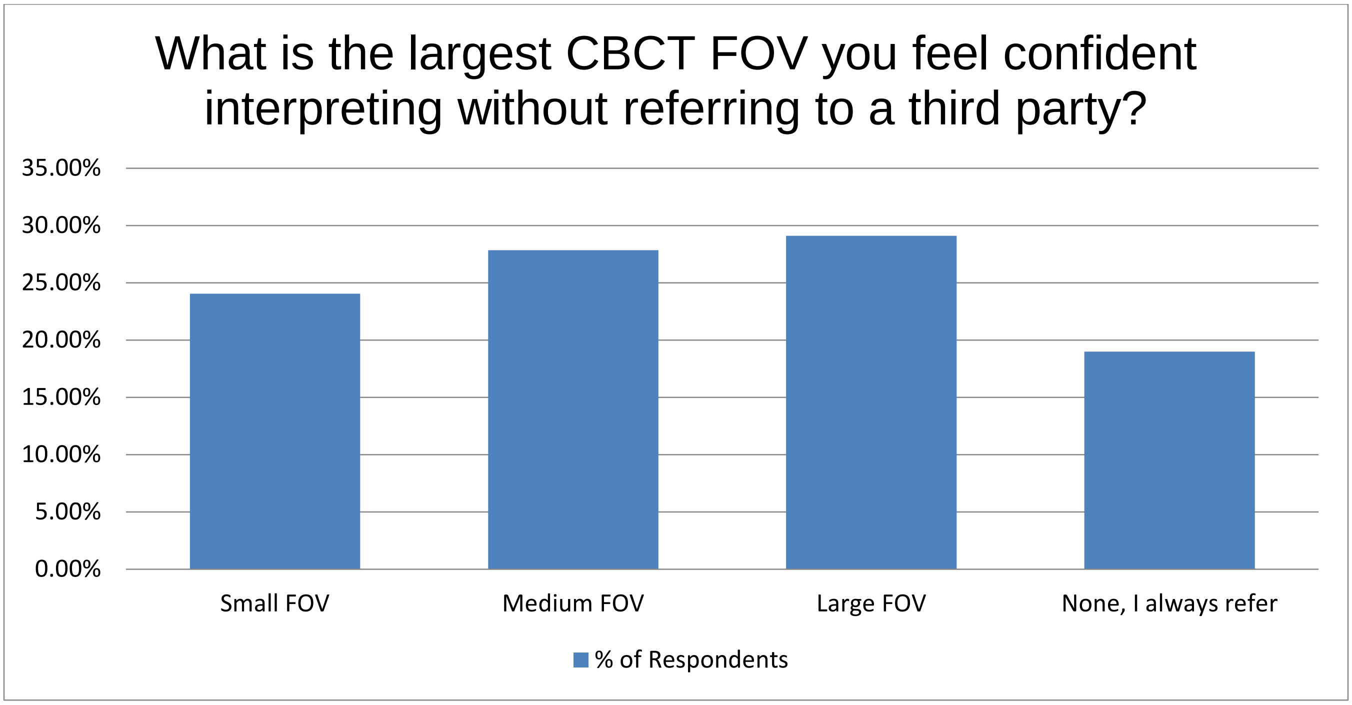


Which CBCT field of view (FOV) do you primarily prescribe?
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Small field (single quadrant)
Medium field (upper and lower jaws)
Large field (craniofacial complex)
% of Respondents

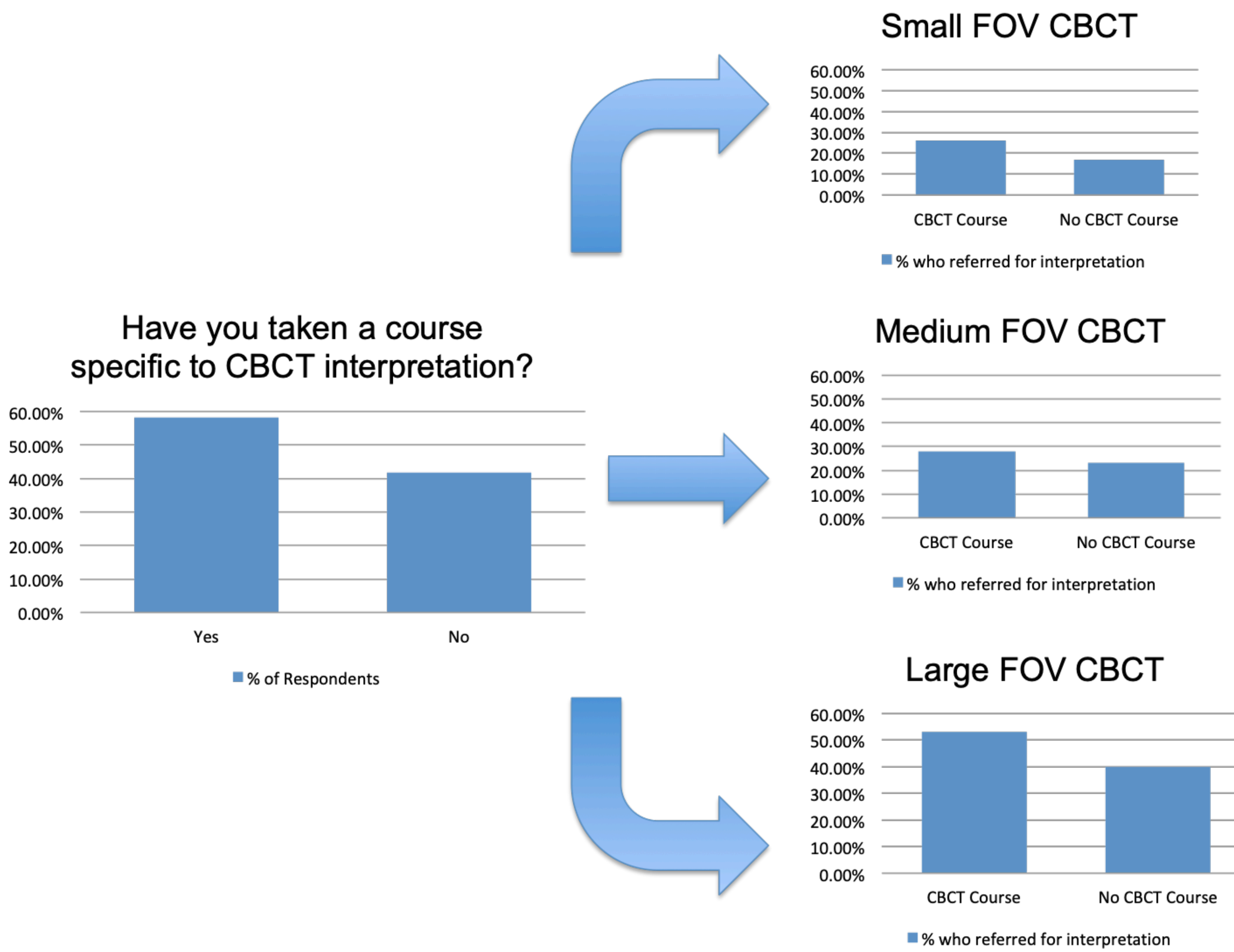
3.


CBCT FOV Primarily Prescribed by Providers
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Small field (single quadrant)
Medium field (upper and lower jaws)
Large field (craniofacial complex)
% of Respondents
CBCT FOV and Interpretation Referral Percentages
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Small field (single quadrant)
Medium field (upper and lower jaws)
Large field (craniofacial complex)
% who referred for interpretation
Third Party Utilized for CBCT Interpretation
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Maxillofacial radiologist
Oral surgeon
Medical radiologist
Other
% of Respondents

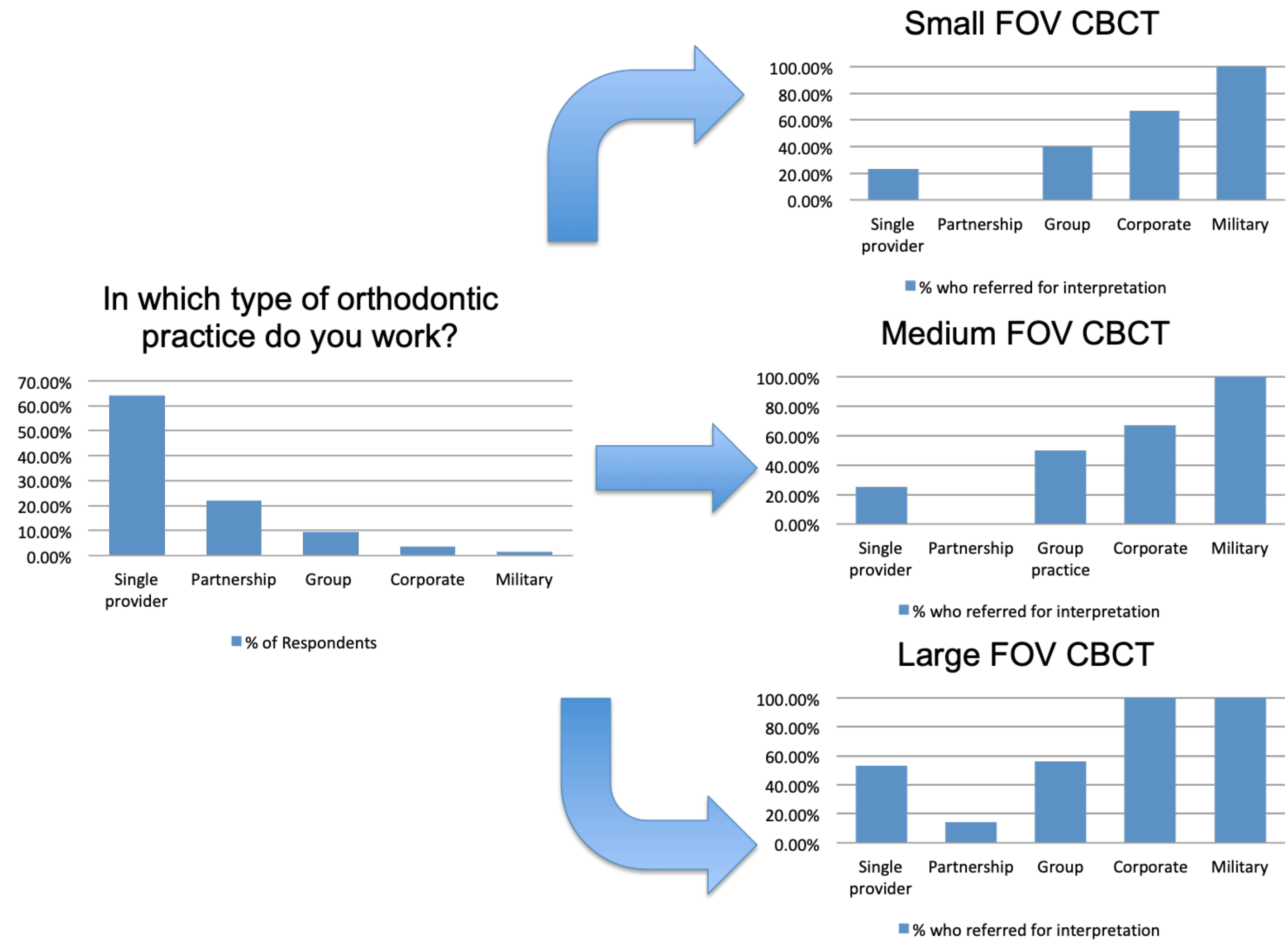
4.


What is the largest CBCT FOV you feel confident interpreting without referring to a third party?
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Small FOV
Medium FOV
Large FOV
None, I always refer
% of Respondents

5.

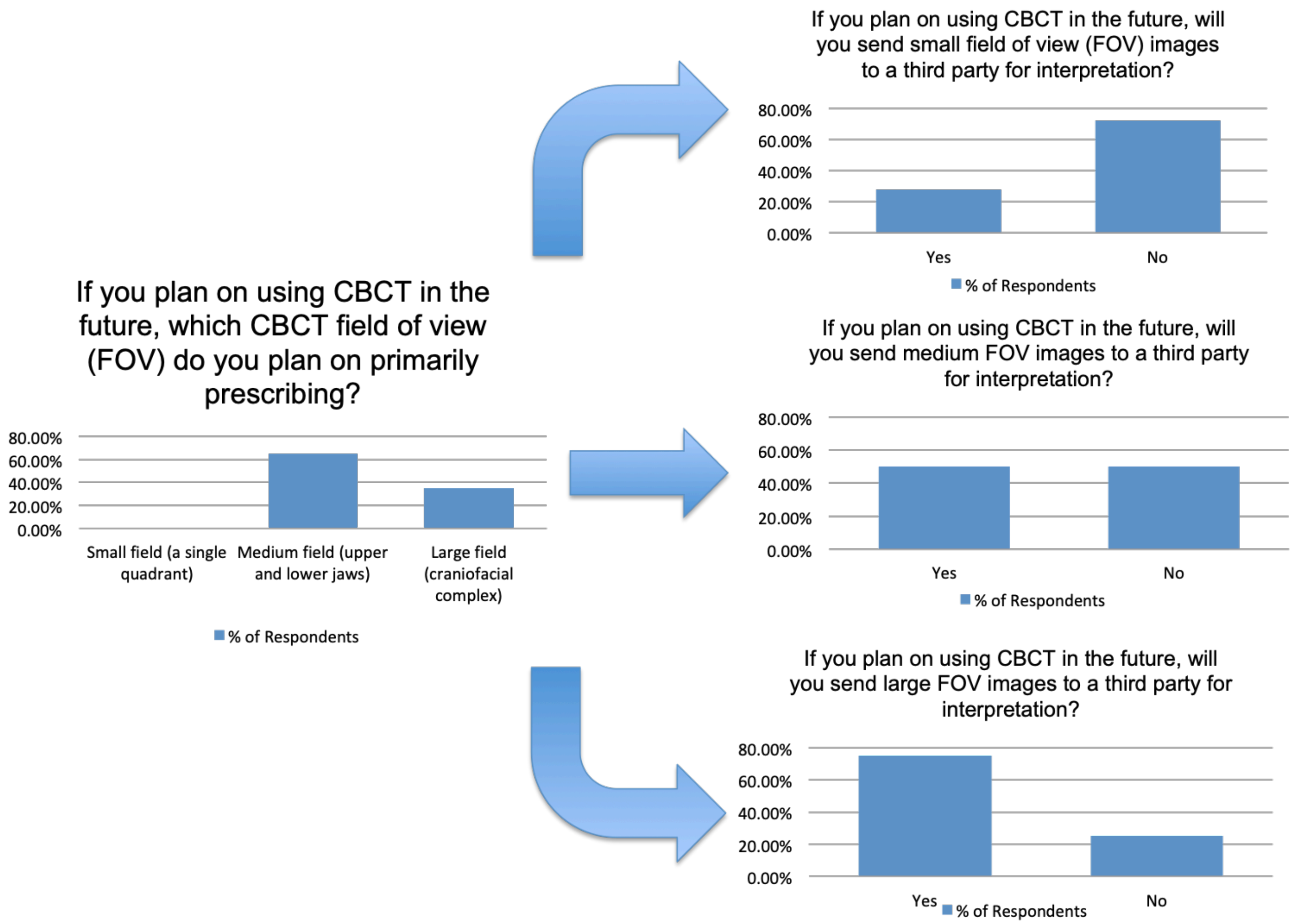

Small FOV CBCT
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
CBCT Course
No CBCT Course
% who referred for interpretation
Have you taken a course specific to CBCT interpretation?
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Yes
No
% of Respondents
Medium FOV CBCT
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
CBCT Course
No CBCT Course
% who referred for interpretation
Large FOV CBCT
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
CBCT Course
No CBCT Course
% who referred for interpretation

6.



Small FOV CBCT
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Single provider
Partnership
Group
Corporate
Military
% who referred for interpretation
In which type of orthodontic practice do you work?
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Single provider
Partnership
Group
Corporate
Military
% of Respondents
Medium FOV CBCT
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Single provider
Partnership
Group practice
Corporate
Military
% who referred for interpretation
Large FOV CBCT
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Single provider
Partnership
Group
Corporate
Military
% who referred for interpretation

7.


If you plan on using CBCT in the future, which CBCT field of view (FOV) do you plan on primarily prescribing?
80.00%
60.00%
40.00%
20.00%
0.00%
Small field (a single quadrant)
Medium field (upper and lower jaws)
Large field (craniofacial complex)
% of Respondents
If you plan on using CBCT in the future, will you send small field of view (FOV) images to a third party for interpretation?
80.00%
60.00%
40.00%
20.00%
0.00%
Yes
No
% of Respondents
If you plan on using CBCT in the future, will you send medium FOV images to a third party for interpretation?
80.00%
60.00%
40.00%
20.00%
0.00%
Yes
No
% of Respondents
If you plan on using CBCT in the future, will you send large FOV images to a third party for interpretation?
80.00%
60.00%
40.00%
20.00%
0.00%
Yes
No
% of Respondents

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