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Selection Criteria and Referral Patterns of Clinicians Utilizing CBCT at UCONN Health Center

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Selection Criteria and Referral Patterns of Clinicians

Utilizing CBCT at UCONN Health Center

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ABSTRACT

The most recent Food and Drug Administration (FDA)/American Dental Association (ADA) guidelines on dental radiograph examinations were released in 2012.[1] Cone beam computed tomography (CBCT) is a three dimensional radiographic exam first introduced in the in the early 2000s.[7] In the 2012 guidelines, CBCT was excluded from the criteria; the guidelines were meant only for "standard dental imaging techniques of intraoral and common extraoral examinations, excluding cone-beam computed tomography."[1]

CBCT is in the armamentarium of radiographs utilized in general dentistry and can be ordered by a dentist, a dental specialist, or dental student. There is a large void in the literature regarding the imaging patterns of CBCT. More data is needed on the clinical indications referred for CBCT, the types of dentists utilizing CBCT, and the patient profiles receiving CBCT exams; this information is essential to updating the FDA/ADA guidelines, for clinicians to understand the spectrum of clinical applications of CBCT, and for the oral and maxillofacial radiologist to understand the patterns and profiles of their referring clinicians.

The objective of this survey is to develop a profile of the clinicians referring patients for CBCT in an academic dentistry setting, the indications for which CBCT exams are being utilized, and patient profiles referred for CBCT. The requisition forms for all CBCT exams acquired at UCONN Health Center were retrospectively analyzed during the time period of June 1, 2015 to May 31, 2016, a total of 590 requisition forms. Overall, the majority of CBCT exams are ordered for implant treatment planning. The second most common indications for CBCT scans was for endodontic diagnosis and treatment planning. The average age of a patient referred for CBCT is 53 years old; however, pediatric patients account for approximately 10% of the CBCT scans. The most frequent referring specialist were from residencies that often placed implants, namely periodontics and prosthodontics residents.

INTRODUCTION

The first radiograph was developed by Wilhelm Conrad Rontgen on November 8, 1895; it was a radiograph of his wife's hand.[5] Within two weeks of the announcement, the first known dental radiograph were exposed by German dentist Otto Walkhoff of the crowns of his maxillary and mandibular incisors, each requiring a 30 minute exposure time.[5] Two months later, another German dentist named Wilhelm Konig had developed a technique that drastically reduced the exposure time to 9 minutes and greatly increased the resolution of the films.[5] Although the first American dentist to exposure the first dental radiograph is uncertain, by April 1896, dental radiographs showing existing fillings and an impacted tooth were on display at the New York Odontological Society.[5]

The incorporation of radiographs in dentistry within one year of its debut is a testament to their usefulness in treating the oral cavity. The utilization of radiographs in imaging of the periodontium were crucial for the comfort of patients and clinicians alike, allowing dentists to better anticipate and plan for patient's needs. Best summarized by American dentist William James Morton, "Painless dentistry is within your grasp by aid of electricity and simple anesthetics and the x ray now rivals your exploring mirror, your probe, your delicate sense of touch, and your keenest power of hypothetical diagnosis."[5]

In the years following intraoral imaging, there were early attempts to image the entire dentomaxillofacial complex. A parabolic radiograph technique was patented in 1922 and the panoramic radiograph was first developed in 1948.[3] Commercial panoramic machines started to become available in the 1960s.[3]

The first radiographic guidelines on selection criteria for asymptomatic teeth were first published by the United States Food and Drug Administration (FDA) in 1987.[4] The guidelines

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were developed to aid in decision making regarding radiation exposure, technique, and likelihood of radiographs aiding in diagnosis of dental disease in the absence of clinical signs and symptoms.[1] The American Dental Association (ADA) endorsed these guidelines in 1989.[4]

By March 2002, the FDA-ADA guidelines were 15 years old and new guidelines were published under the ADA guidelines. The 2002 ADA guidelines were updated and expanded to include panoramic radiography and vertical bitewings.[4] In addition, selection criteria were expanded for temporomandibular joint disorders, trauma, and tumors. For the first time ever, imaging recommendations for implants were included, with the guidelines citing, "Clinical judgement as to the need and type of radiographic images" needed for implant treatment planning.[4]

In 2012, the ADA guidelines were again updated. However, guidelines only dealt with "standard dental imaging" and explicitly excluded cone-beam computed tomography, citing that the indications for CBCT are not well-developed.[1]

Cone beam computed tomography was first introduced to dentistry in the early 2000s.[7] CBCT is a three dimensional imaging technique available to dentists if needed. There are several clear advantages of CBCT over traditional 2D imaging, including controlled magnification, lack of superimposition, and multiplanar reconstructions.[7] While many areas of dentistry can benefit from 3D imaging, CBCT is far from replacing traditional dental imaging for a number of reasons, including higher machine costs and maintenance costs, prolonged exposure time, increased time to manipulate and interpret images, and decreased diagnostic ability due to dental metallic artifact.[7]

There are clinical indications why a dentist would opt for CBCT imaging over traditional imaging. However, the most current FDA/ADA imaging guidelines do not include selection criteria or indications for CBCT. Comparatively, in 2012, the European Commission released the

Radiation Protection No. 172: Cone beam CT for Dental and Maxillofacial Radiology (Evidence-based Guidelines) which includes detailed selection criteria regarding CBCT imaging.[2] The recommendations specific for CBCT are based on reviewing the available case reports with indications as to the strength of the recommendation.[2]

While case reports regarding the utilization of CBCT exist, there is a large void in the literature regarding the imaging trends or the referral patterns for CBCT. The aim of this survey is to identify the clinical situations for which clinicians are utilizing CBCTs, what areas of dentistry are utilizing CBCT, and the demographics of patients being imaged with CBCT at the University of Connecticut Health Center (UCHC) (now named "UCONN HEALTH").

The collection and analyses of this information is important on many levels. First of all, this information could potentially shape future imaging guidelines. Second, the identification of the dental specialties most utilizing CBCT and their clinical indications will foster discussion between the clinician and an oral and maxillofacial radiologist (OMR). Thirdly, in generating a patient profile, the imaging needs of patient by age demographics can be visualized and the advanced imaging needs of the pediatric patients to the adult population can be compared.

OBJECTIVES

The objectives of this study were to determine the selection criteria of patients imaged with CBCT at UCHC and to define the referral patterns of dentists and dental specialists utilizing CBCT.

SPECIFIC AIMS

1. To identify the distribution and proportion selection criteria used for prescribing CBCT.
2. To identify the distribution and proportions of the dental specialists utilizing CBCT.
3. To describe the demographic profile of patients being referred for CBCT.

HYPOTHESIS

This is a descriptive study. No hypothesis were tested.

The goal of this survey was to describe a profile of clinicians referring patients for CBCT, the selection criteria for which CBCT is being utilized, and a demographic profile of patients referred for CBCT. This information is not currently available in the literature. These current trends are important so that formal CBCT imaging guidelines can be developed, dental educational curricula can be adjusted to reflect the changing imaging demands, and so the oral and maxillofacial radiologist can be familiarized with the array of clinical scenarios for which they are likely to be consulted.

MATERIALS AND METHODS

The study received approval from the Institutional Review Board (IRB) of the University of Connecticut Health Center's Human Subject Protection Office as an exempt study. The requisition forms of all CBCT exams acquired at UCHC for the period of June 1, 2015 to May 31, 2016. The data fields to be collected were identified prior to reviewing the requisition forms. For patient's demographics, the patient's gender and age the day the CBCT was acquired were recorded.

For the referring clinician, the specialty of the clinician was recorded based off their respective specialty training program or their faculty position by department. Internal scans had three possible names to be included: a student, a resident, and a faculty provider. Due to the nature that is academic institutions, many forms had at least two providers listed. If a predoctoral student was listed, they were considered the primary provider (as predoctoral students require a second signature when ordering CBCTs). If a resident's name was present alone, the resident was considered the primary provider. If a resident was listed with a faculty provider, the resident was still considered the main provider. If a faculty's name was listed alone, the faculty was deemed the main provider. For outside providers, the specialty of the practice was almost always indicated on the referrals form (i.e. Smith Endodontics) and crosschecked by visiting the provider's website where the provider biographies always specified their specialty training.

For the field-of-view, the size of the scan used in image acquisition was recorded. In the case of orthognathic surgical cases, two scans are to be acquired in order to capture the entire cranium. For these cases where two scans were acquired for a single case, the field of view used was only counted once.

The electronic requisition forms at UCHC have a section in which the referring clinician can select a box for reason for scan (i.e. implant, endodontic evaluation, etc). In addition, there is a free response section where the provider can include any additional information. If present, the free response selection criteria was recorded. Most CBCT scans were acquired with a single treatment aim in mind. Occasionally, a single scan can satisfy multiple selection criteria (i.e. impacted #29 with evaluation of dense bony island on #30). In these cases, the first indication listed was considered the primary reason for the scan and determined how a scan would be classified.
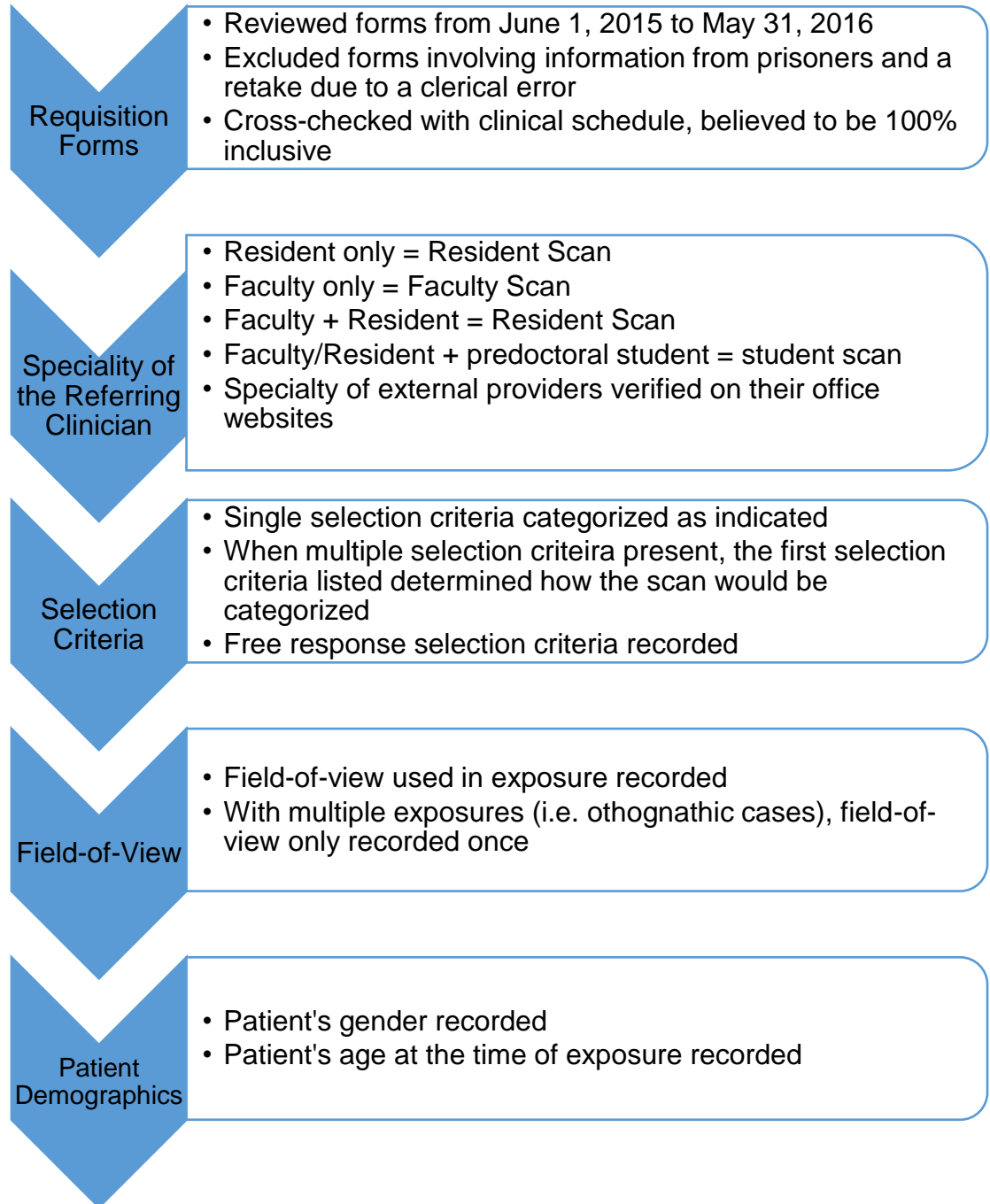
During the review of the requisition forms, the forms were cross-checked with the clinic schedule. In this way, the sample study is believed to be 100% inclusive.

The goal of this study was to acquire a recent profile of CBCT referral patterns of clinicians. This study period accounts for the time period of June 1, 2015 to May 31, 2016. One complete calendar year encompassed the start and end of academic programs. This was meant minimize any bias that a shorter study period could have due to fluctuations within the academic year.

In all, 596 requisition forms were reviewed. One form was not included, as it was a retake due to a clerical error; the proper scan was included in the analysis. Five forms involved information from prisoners and were eliminated per IRB approval.

Figure 1 visually demonstrates the methodology used in the data collection.

Figure 1: Methodology of Materials and Methods

- Reviewed forms from June 1, 2015 to May 31, 2016
- Excluded forms involving information from prisoners and a retake due to a clerical error
- Cross-checked with clinical schedule, believed to be 100% inclusive

Requisition Forms

- Resident only = Resident Scan
- Faculty only = Faculty Scan
- Faculty + Resident = Resident Scan
- Faculty/Resident + predoctoral student = student scan
- Specialty of external providers verified on their office websites

Speciality of the Referring Clinician

- Single selection criteria categorized as indicated
- When multiple selection criteira present, the first selection criteria listed determined how the scan would be categorized
- Free response selection criteria recorded

Selection Criteria

- Field-of-view used in exposure recorded
- With multiple exposures (i.e. othognathic cases), field-of-view only recorded once

Field-of-View

- Patient's gender recorded
- Patient's age at the time of exposure recorded

Patient Demographics

RESULTS

Five hundred ninety requisition forms were used in the final analysis.

Field of View

CBCT scans are capable of being collimated to a variable size and this gives a variety of different field of views. During the time of this study period, there were two CBCT machines being used to acquire patient images with the second machine functioning for only a few weeks of this study period. Most scans (approximately 94%) were acquired by the Morita Accuitomo 170 CBCT unit. The distribution for field of views (FOV) as captured predominately on the Morita Accuitomo 170 CBCT Unit is shown in Figure 1.

Figure 2: Distribution of Field-of-Views
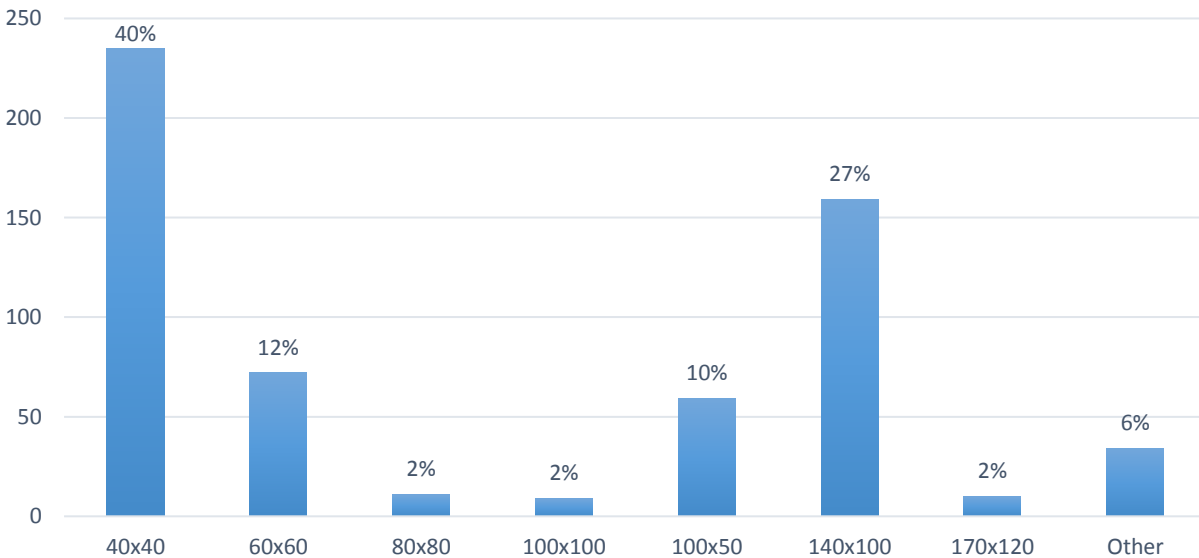
Figure 2 shows that the majority of the scans are acquired with a 40x40 field-of-view, followed by 140x100. Together, these two sizes accounted for two thirds of all CBCT acquisitions.

<u>Selection Criteria for CBCT Referral</u>

Eleven major categories for CBCT referral were identified:

1. **Implants.** These were patients referred for CBCT for implant treatment planning.

2. **Endodontic scans**. Included scans that were acquired for suspected tooth fracture, post perforations, evaluation of unusual root configuration, internal or external root resorption, persistent periapical radiolucencies on endodontically treated teeth, suspected "missed" canals, calcified canals requiring canal identification, or a persistent pain referral from an endodontic provider. Endodontic scans had the most varied selection criteria, discussed later.

3. **Impacted tooth**. This included impacted tooth or supernumerary evaluation. This category also included ectopically erupting teeth and impacted canine exposures requiring additional imaging.

4. **Infection**. This included scans acquired for perimplantitis, failing implants, abscess, osteomyelitis, swelling in the absence of lesion or cyst, and osteonecrosis (ONJ) or medication-related ONJ (MRONJ).

5. **Pathology**. This included any scan that was acquired using the words "lesion" or "cyst," description of an aggressive anomaly previously noted from prior imaging, or evaluation of a lesion with a known diagnosis from prior incisional biopsy.

6. **Third molar evaluation**. This included any third molar (maxillary or mandibular) evaluation with or without inferior alveolar nerve canal (IAC) relationship evaluation.

7. **Surgical treatment planning**. This included scans acquired for orthognathic treatment planning, apicoectomy treatment planning, or dental transplantation treatment planning.

8. **Trauma**. This included scans where trauma was the only indication or recent trauma with suspected or previously identified dental, alveolar, mid-face, or mandibular fractures.

9. **Follow up from previous imaging**. Abnormality noted on previous imaging not described as "lesion" or "cyst" that required further evaluation.

10. **TMJ Evaluation**. This included scans where temporomandibular joint (TMJ) evaluation was the first or only selection criteria.

11. **Research**. Research is a part of any academic institution. There were two separate implant studies being conducted during the time of this study period that required CBCT acquisitions on patients. These research scans have been separately included in a research category.

12. **Other**. Remaining scans not described by the above categories.

With these categories assigned as described above, Figure 3 shows the distribution of clinical indications for CBCT referral.

Figure 3: Distribution of Selection Criteria for All CBCT Acquisitions
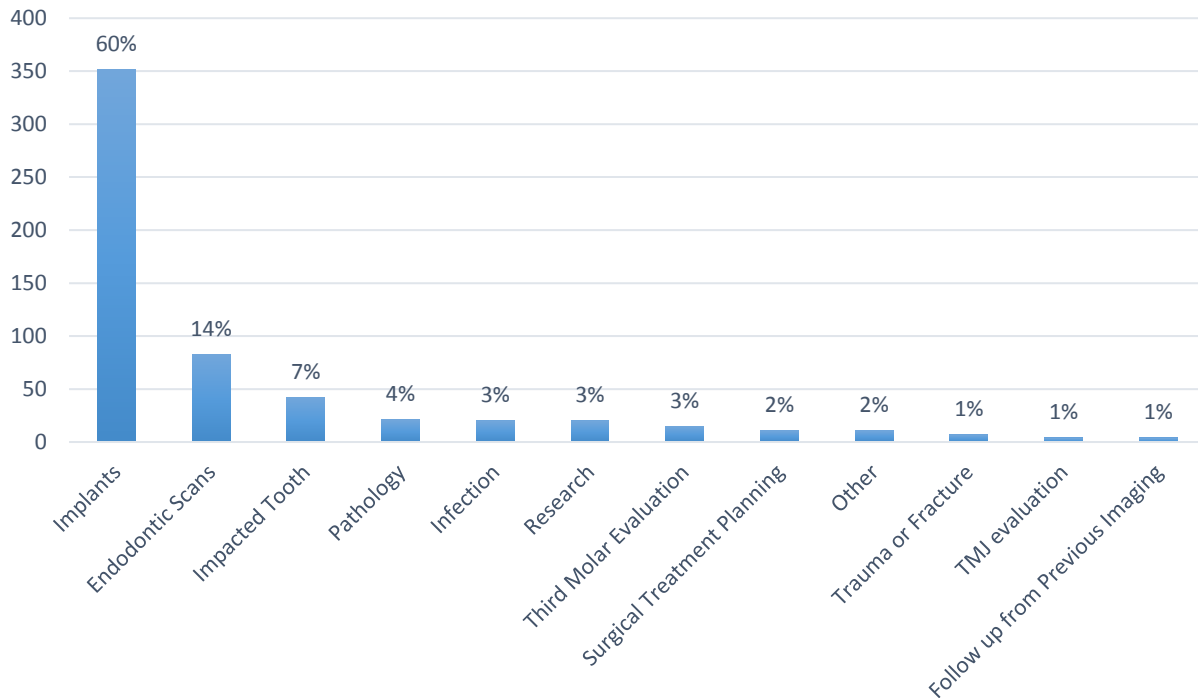
Figure 3 shows that the primary indication for CBCT acquisition is implant treatment planning.

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To better visualize the scans acquired for reasons other than implant treatment planning, Figure 4 shows the selection criteria of the 238 scans acquired for reasons other than implants. Percentages shown are percentages of all CBCT acquisitions.

Figure 4: Distribution of Selection Criteria for CBCT Not Depicting Implants
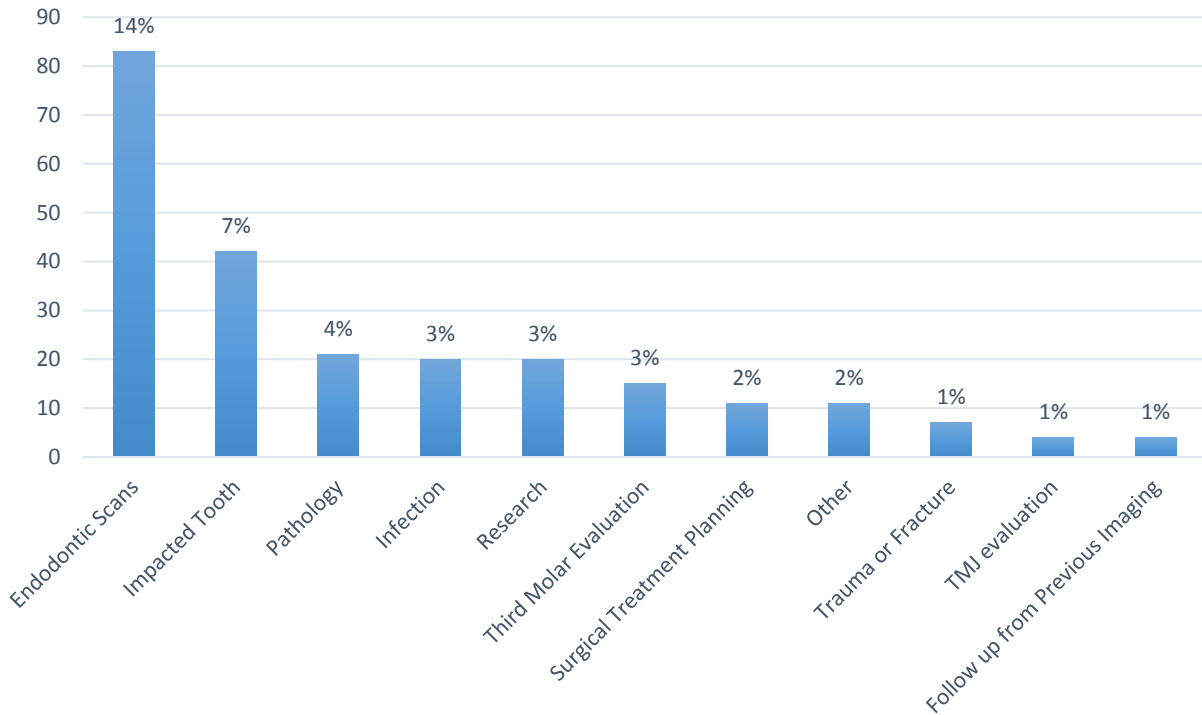
Figure 4 shows the second and third most common selection criteria for CBCT evaluation were endodontic scans and impacted tooth evaluation, respectively.

Scans acquired for implant treatment planning can be further described by their desired implant locations. Figure 5 shows the distribution of all implants CBCT scans based off of the location of the future implant.

Figure 5: CBCT Acquisitions by Future Implant Locations
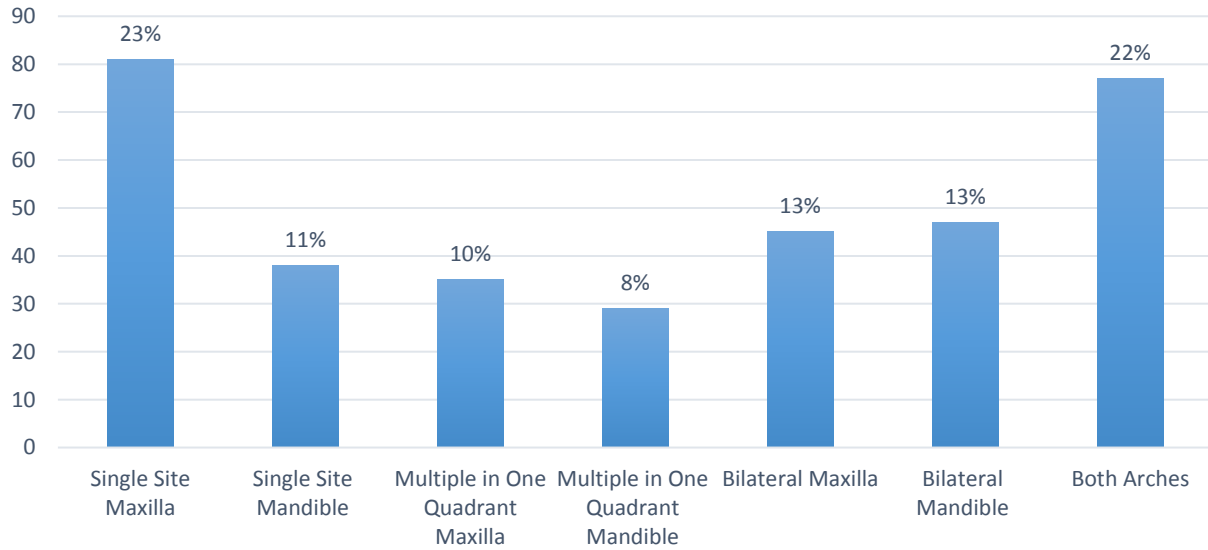
Figure 5 shows that implant treatment planning for a single site maxilla was the most common implant site for CBCT evaluation, closely followed by implant treatment planning in both arches. Of note, there were zero CBCT scans acquired where temporary anchoring devices (TADs) were the primary indication.

There were 83 scans classified as "endodontic scans," which was the second most common reason for CBCT referral. Scans classified as "endodontic scans" represented a wide array of dental problems, both in the diagnosis to establish a treatment plan and in the post-operative management of endodontic therapy. The wide spectrum that encompasses odontogenic pain and endodontic therapy gives "endodontic scans" the most varied selection criteria. Of note, endodontic providers most often provided clinical histories, current clinical findings, and either a differential or working diagnosis, or combinations thereof. As a result, the selection criteria provided by the endodontic providers were the longest and most verbose compared to other dental providers.

Endodontic scans can be broken down by their pretreatment, intra-treatment, and post-treatment acquisition.

Pre-treatment scans included those acquired to establish a diagnosis or to aid in the endodontic treatment prior to initiating treatment. By and large, 69 of the 83 endodontic scans (83.1%) were acquired on the basis of "pre-treatment."
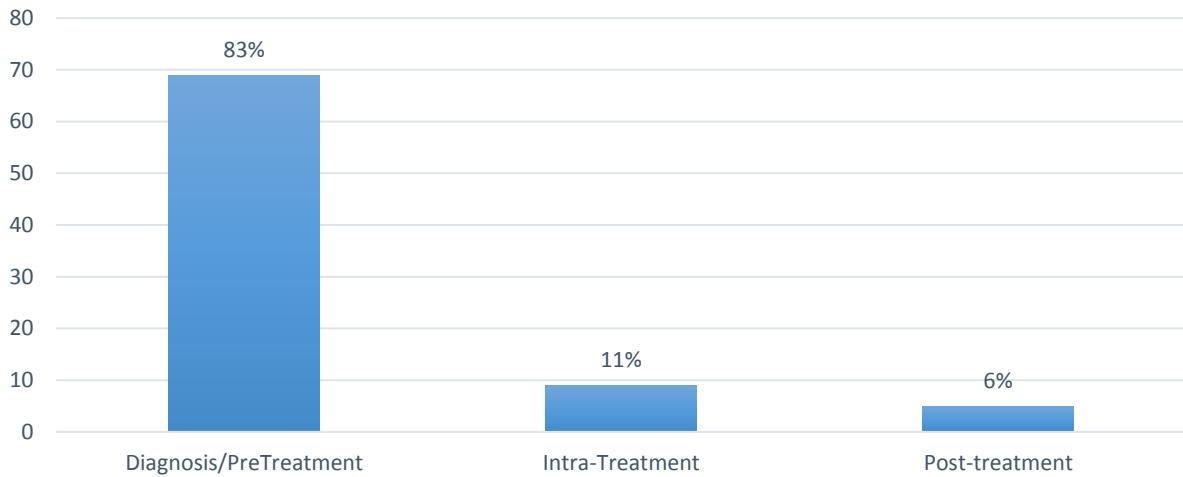
Intra-treatment endodontic scans are scans acquired after the initiation of endodontic therapy and before the final obturation was completed; this represented 9 scans (10.8%) of the endodontic scan sample. Reasons for an intra-treatment endodontic scans included perforation of a root wall during the endodontic therapy, unable to localize single or multiple canals, initiation of endodontic therapy revealed pre-existing root canal perforations, and persistent pain following cleaning and shaping with calcium hydroxide. Canal localization was the most common intra-treatment acquisition.

Post-treatment endodontic scans are scans acquired after the completion of endodontic therapy that was described as "recent" by the referring provider or when the provider included an endodontic treatment date that was less than a year from the time of the CBCT referral.

Post-treatment scans represent 5 scans (6%) of the endodontic scans. All of the post-treatment endodontic scans were acquired for persistent pain on a recently endodontically treated tooth. The pain was most often described as persistent pain; however, some providers specified pain on percussion only or pain on palpation in the mid-root buccal region.

Figure 6 shows the distribution of CBCT scans acquired for endodontic indications relative to treatment initiation.

Figure 6: CBCT Acquisitions Relative to Initiation of Endodontic Treatment

While most endodontic scans were acquired on the basis of diagnosis or pre-treatment, 11% were acquired intra-treatment and 6% were acquired post-treatment.

Of the 590 scans, 42 scans were referred for "impacted tooth." For impacted teeth, the distribution of CBCT acquisitions based on the location of teeth was as follows. Note the abbreviations maxillary (mx) and mandibular (md).

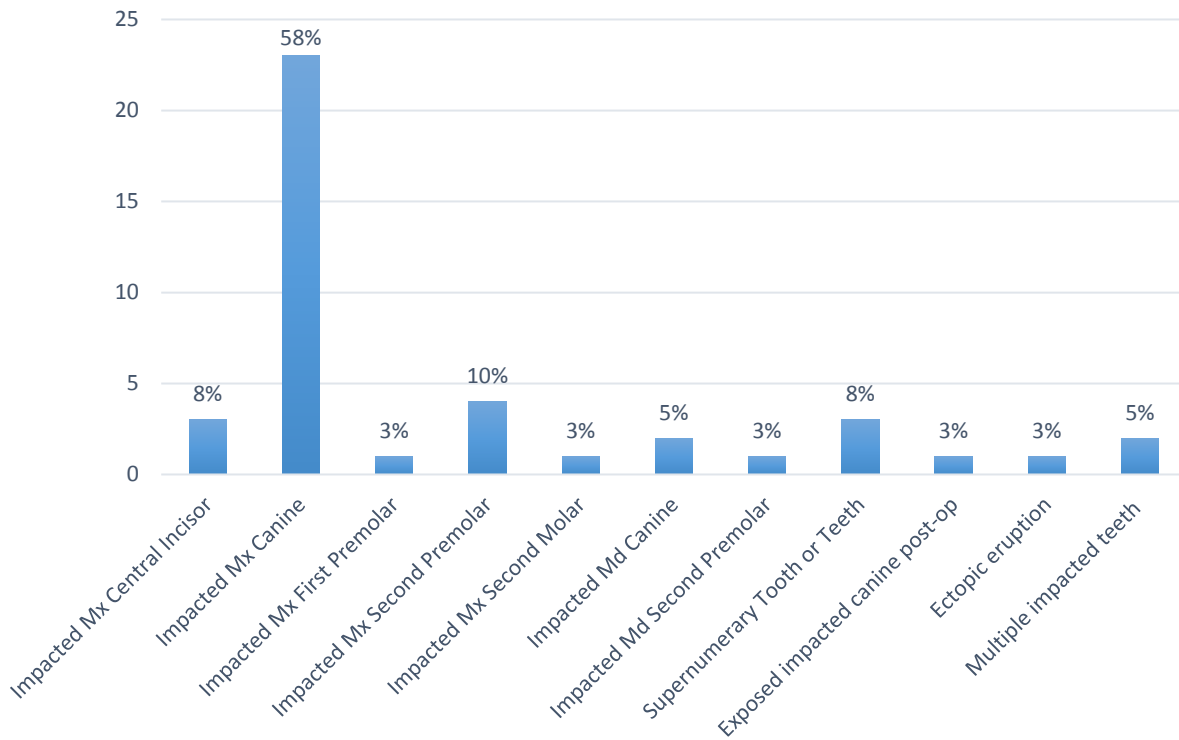**Figure 7:** CBCT Acquisitions of Impacted Teeth by Location

Figure 6 shows that majority CBCT scans acquired for an impacted tooth were for an impacted maxillary canine. The second most common tooth was an impacted second maxillary premolar. CBCT scans were not acquired for any of the following impacted teeth: maxillary lateral incisors, maxillary first molars, mandibular central or lateral incisors, mandibular first premolars, or mandibular first or second molars.

Third molars were classified in a separate category other than impacted teeth. There were 15 CBCT acquisitions for third molar evaluations. Figure 7 shows the distribution of scans acquired for evaluation of third molars by location.

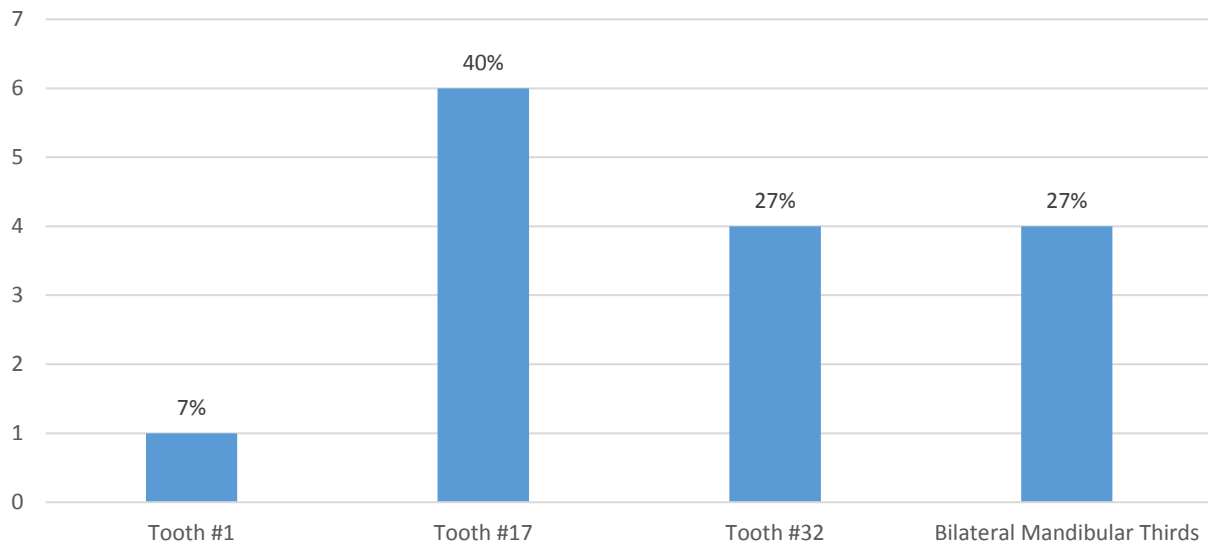**Figure 8**: CBCT Acquisitions by Third Molar Location

Figure 8 shows that approximately two-thirds of third molar evaluations involved a unilateral mandibular third molar only, with bilateral mandibular thirds indicated for approximately 27% of scans.

For scans classified as infections, the free response section of requisition forms often but not always had supplemental information provided by the referring clinician. The provider might have included more extensive patient histories (i.e. history of breast cancer, intravenous bisphosphonates, recent extraction with pain) in addition to "rule out ONJ." The "known ONJ" category includes patients with a history of ONJ, known ONJ, or where ONJ was the only selection criteria indicated.

Figure 9: CBCT Acquisitions for Various Infections
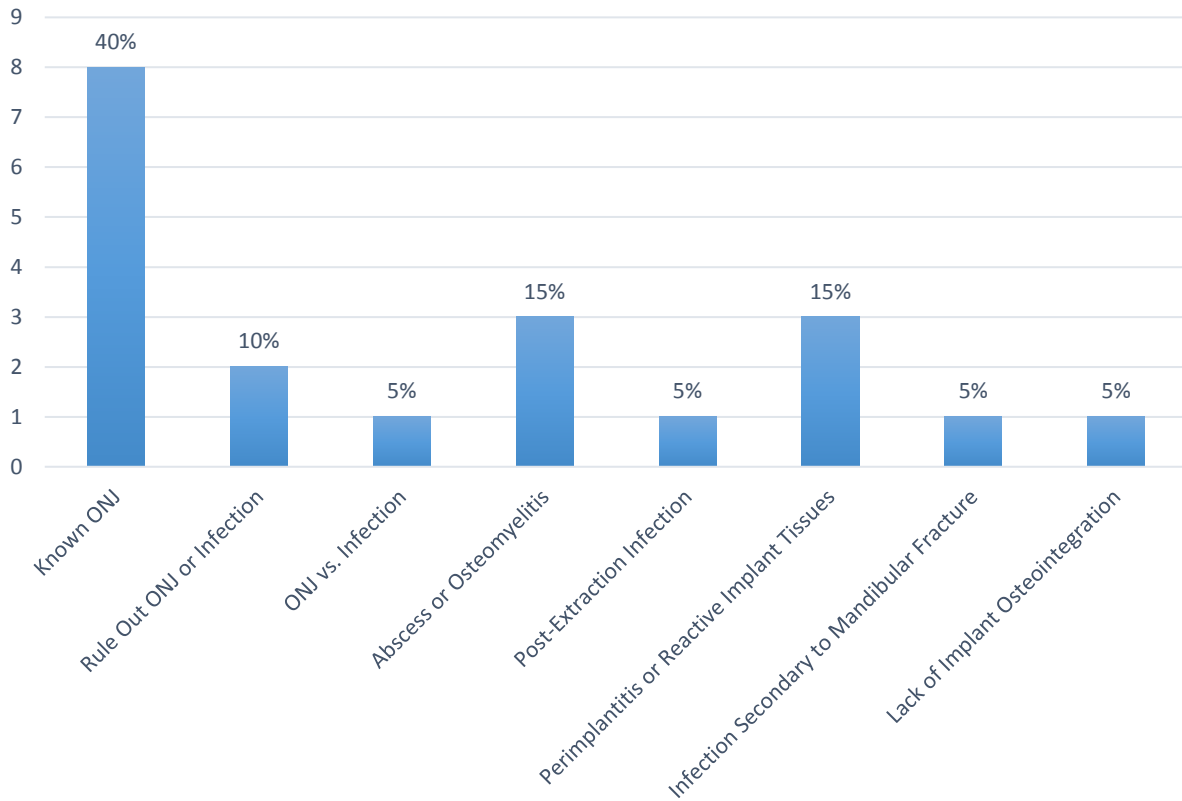
Figure 8 shows that the most common infection for CBCT acquisition was for ONJ, with the second most common indications being equally abscess/osteomyelitis and peri-implantitis.

Figure 10 shows the distribution of CBCTs acquired for surgical treatment planning for various surgeries. A single CBCT was acquired for condylar asymmetry surgical planning which was specifically indicated as "surgery not specified." The two CBCT scans acquired for "reconstruction" were both for reconstructions following resections of large odontogenic keratocysts (OKCs). A single CBCT was acquired for a dental autotransplant case.

Figure 10: CBCT Acquisition for Surgical Treatment Planning
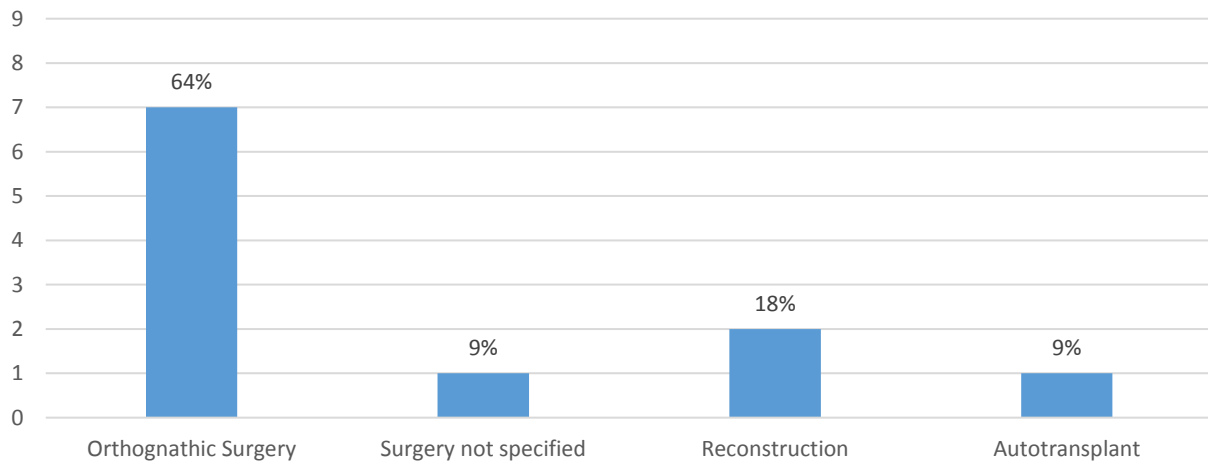
Figure 10 shows that the majority of CBCT acquisitions for surgical treatment planning were for planning for orthognathic surgery treatment planning.

<u>Specialty of Referring Clinician</u>

Of the 590 requisition forms, 17 different categories of providers were identified.

Residents were a common requesting provider. From most requested to least requested resident provider, they were periodontic (21%), prosthodontic (14%), advanced education in general dentistry (AEGD) (13%), endodontic (7%), orthodontic (6%), and oral and maxillofacial surgery (OMFS) residents (3%). Approximately 3% of the total scans were requested with a predoctoral dental student acting as the referring provider.

Faculty in the specialty programs were also a common requesting provider. OMFS faculty were the most common faculty referring provider (9%), followed closely by prosthodontic faculty (7%). Orthodontic faculty made up approximately 1% of referring providers.

A number of private practitioners referred their patients to UCHC for CBCT acquisition. Private practice endodontists were the most common private practitioner referring for CBCT, accounting for approximately 7% of the scans, followed by private practice periodontists (5%), private practice general dentists (3%), and private practice OMFS (2%).

Approximately 1% of the scans were requested from "faculty practice," an in-house general dentistry clinic were the care is provided by dental faculty rather than dental students or dental residents.

Of note is the "miscellaneous" category. This category consists of 3 scans from 3 different providers. One request was from a Doctor of Osteopathic Medicine (DO) who requested analysis for obstructive sleep apnea after the patient was unable to complete a sleep study. One request was from a chiropractor for a TMJ evaluation for clicking, popping, and an uneven bite. One request was from a private practice pediatric dentist for evaluation of impacted #6. The distribution of specialists referring for CBCT is show in in Figure 10.
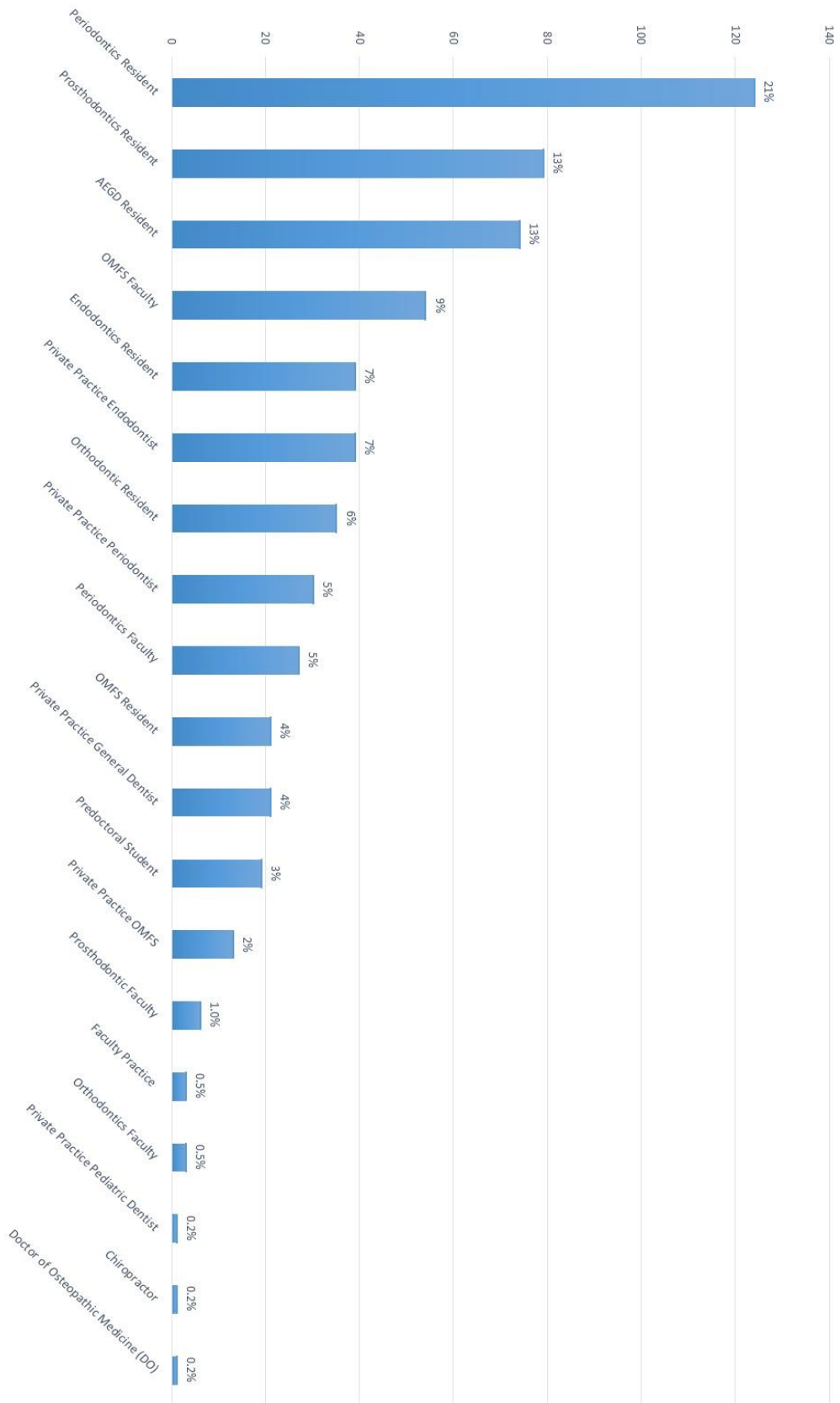
20

Figure 11: Specialty of All Referring Providers for CBCT

Periodontics Resident — 21%
Prosthodontics Resident — 13%
AEGD Resident — 13%
OMFS Faculty — 9%
Endodontics Resident — 7%
Private Practice Endodontist — 7%
Orthodontic Resident — 6%
Private Practice Periodontist — 5%
Periodontics Faculty — 5%
OMFS Resident — 4%
Private Practice General Dentist — 4%
Predoctoral Student — 3%
Private Practice OMFS — 2%
Prosthodontic Faculty — 1.0%
Faculty Practice — 0.5%
Orthodontics Faculty — 0.5%
Private Practice Pediatric Dentist — 0.2%
Chiropractor — 0.2%
Doctor of Osteopathic Medicine (DO) — 0.2%

The majority of the scans were referred from providers internally located within UCHC. Of the 590 scans, 484 scans (82%) came from internal providers and 106 scans (18%) came from providers externally located from UCHC.

Figure 11 shows the distribution of specialists internally located within UCONN Health Center.

**Figure 12:** Distribution of Providers Internal to UCONN Health Center
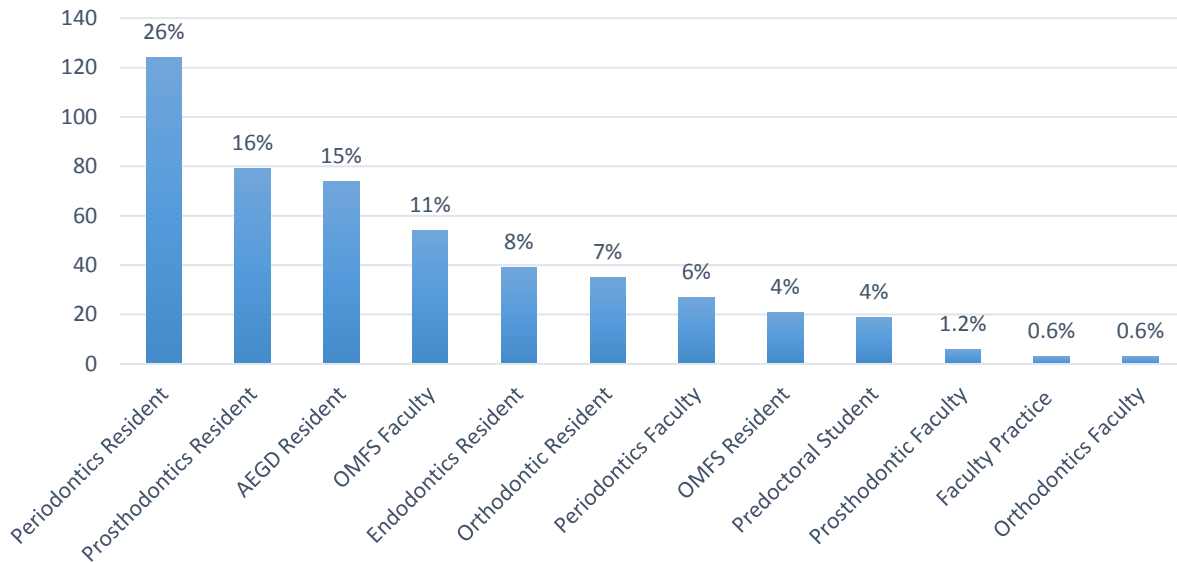
Figure 12 shows that the most common internal provider for CBCT evaluation were periodontics residents. Endodontic residents were the fifth most common internal provider.

Figure 13 shows the distribution of practitioners externally located from UCONN Health Center who referred for CBCT scans.

Figure 13: Distributions of Providers Externally Located to UCONN Health Center
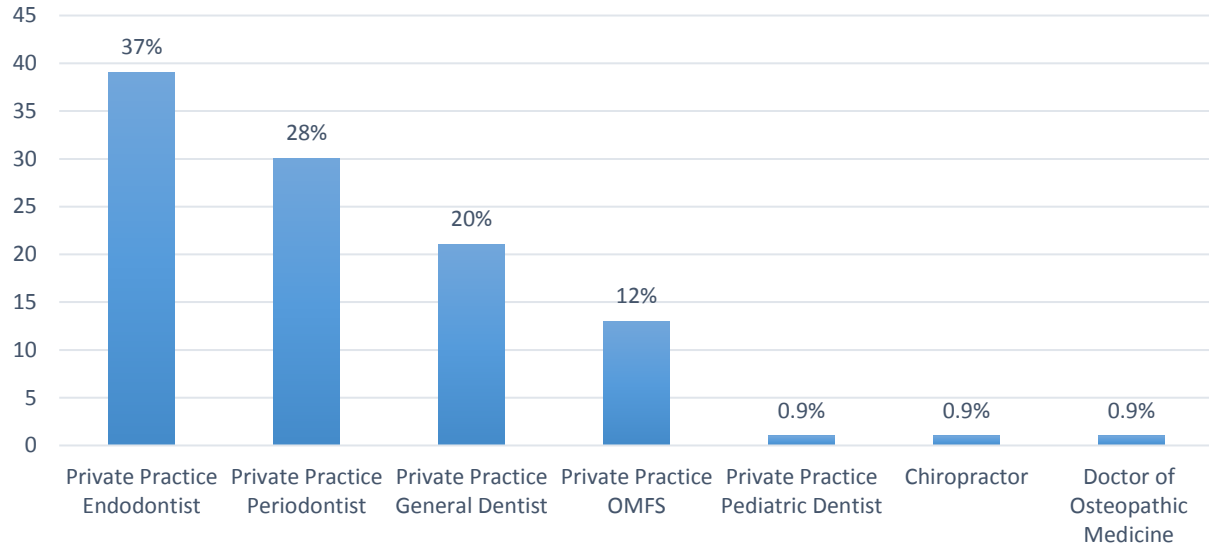
Unlike internal providers, the most common provider externally located from UCHC were private practice endodontists who were a more common referrer than private practice periodontists.

In regards to the providers, each provider type can be evaluated by the types of scans being referred for.

Periodontics residents made up 21% of the overall CBCT referrals. Overwhelmingly, periodontics residents ordered CBCT scans for implant treatment planning. Figure 13 shows the distribution of CBCT referrals from periodontics residents with implants scan separated by location.

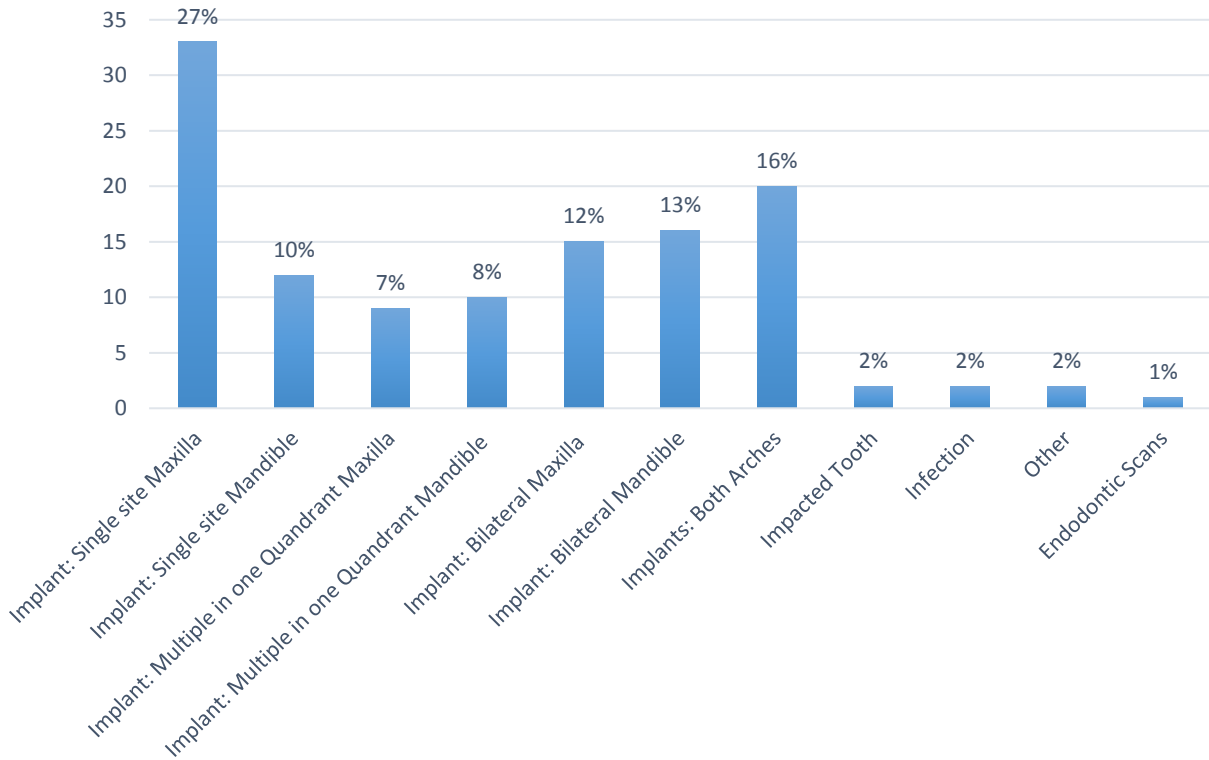**Figure 14**: Selection Criteria Requested By Periodontics Residents

Figure 13 shows that the most common CBCT referral from a periodontics residents was a single site maxillary implant treatment planning.

The two impacted tooth scans were acquired for impacted maxillary canines. The endodontic scan was acquired for fractured tooth likely to be replaced with implant. The two infection scans were both acquired for perimplantitis. The scans in the other category were for retained root tips and for mobile teeth with no signs of active periodontitis.

Of note, 13% of the CBCT referrals from periodontics residents included "additional selection criteria." Additional selection criteria are criteria that are insufficient for a CBCT scan on their own but can be included when they would be incidentally captured. An example of additional selection criteria would be, "implant treatment planning sites #2, 3 with evaluation of existing implant at site #4." A CBCT acquisition for an existing implant in the absence of clinical findings is insufficient but when it will be incidentally captured in the field of view, the provider is indicating they would like this implant to be evaluated where possible.

By and large, the most common additional selection criteria used by periodontics residents is planned or possible sinus augmentation (11% of scans). However, one referral asked for evaluation of an endodontically treated tooth and another single referral asked for evaluation of existing implants.

Figure 15: Field-of-Views Obtained For Periodontics Residents
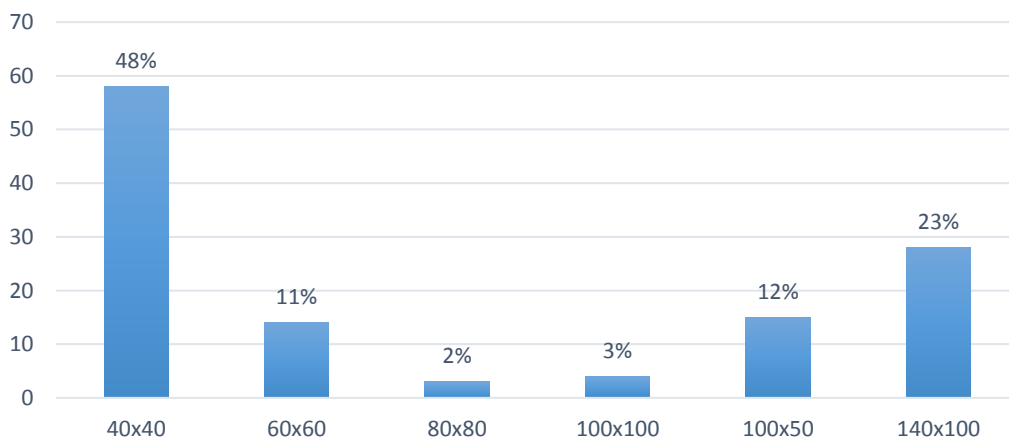
www.manaraa.com

Figure 15 shows that nearly half the scans referred by periodontics residents were a 40x40 field of view.

Prosthodontic residents are the second most common provider for CBCT referrals. Again, implants were the most common selection criteria. Figure 16 shows the distribution of selection criteria from prosthodontic residents with implants separated by location. There was a study involving CBCT acquisitions during this study time period carried out by the prosthodontics department which accounted for the "research" category.

Figure 16: CBCT Referrals From Prosthodontic Residents
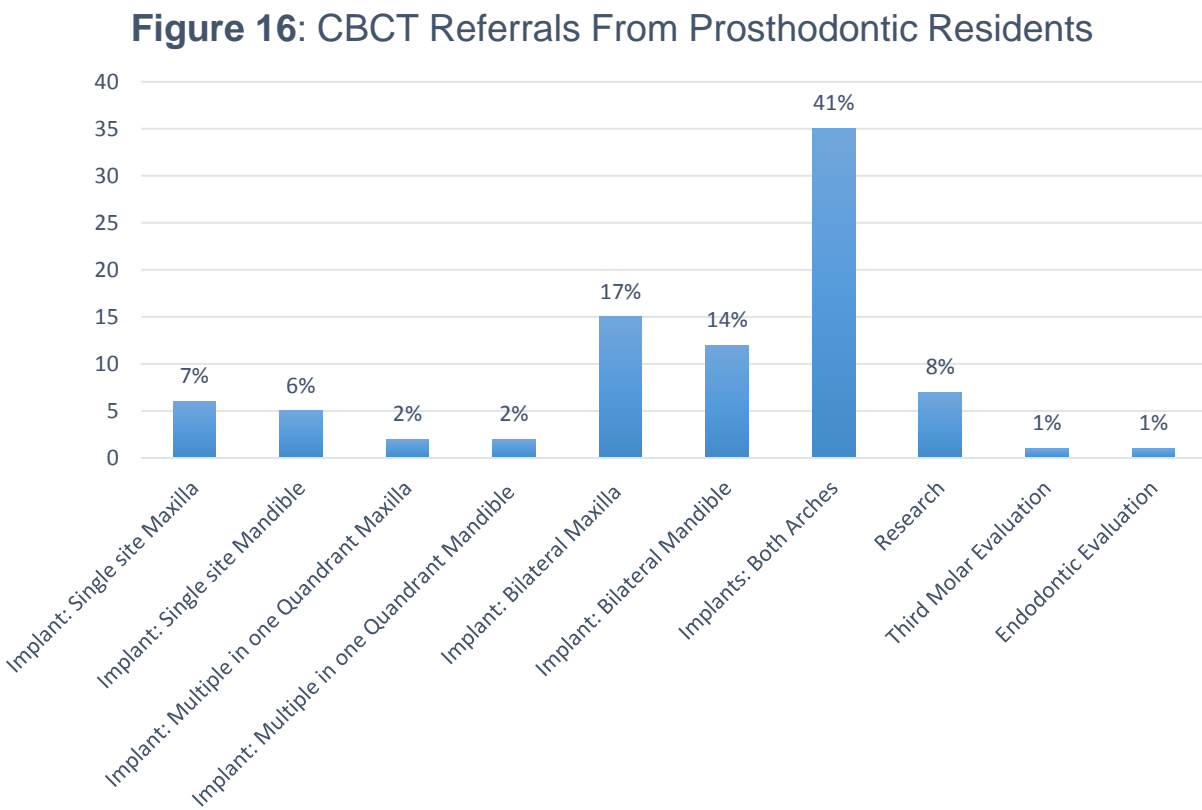
Like periodontics residents, implants were the main indication for CBCT referral of prosthodontic residents. However, approximately 41% of referrals from prosthodontic residents were for implants involving both arches.

The field-of-views obtained for prosthodontic residents are shown in Figure 17.

Figure 17: Field-of-Views Obtained for Prosthodontic Residents
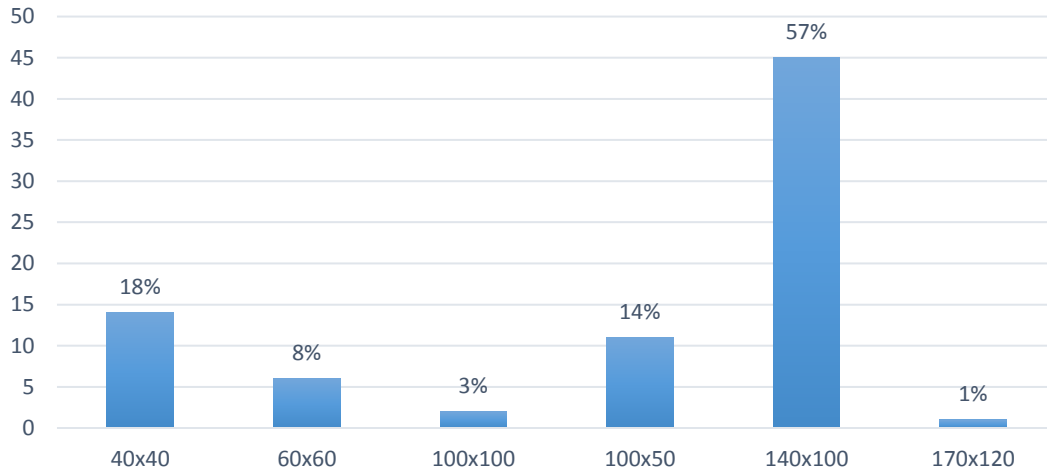
Unlike periodontics residents, prosthodontics residents were obtaining larger field-of-views, which coincides with implant treatment planning of both arches.

AEGD residents were the third most common provider for CBCT referral. Figure 18 shows the distribution of selection criteria of AEGD residents with implants separated by location.

Figure 18: Selection Criteria from AEGD Residents
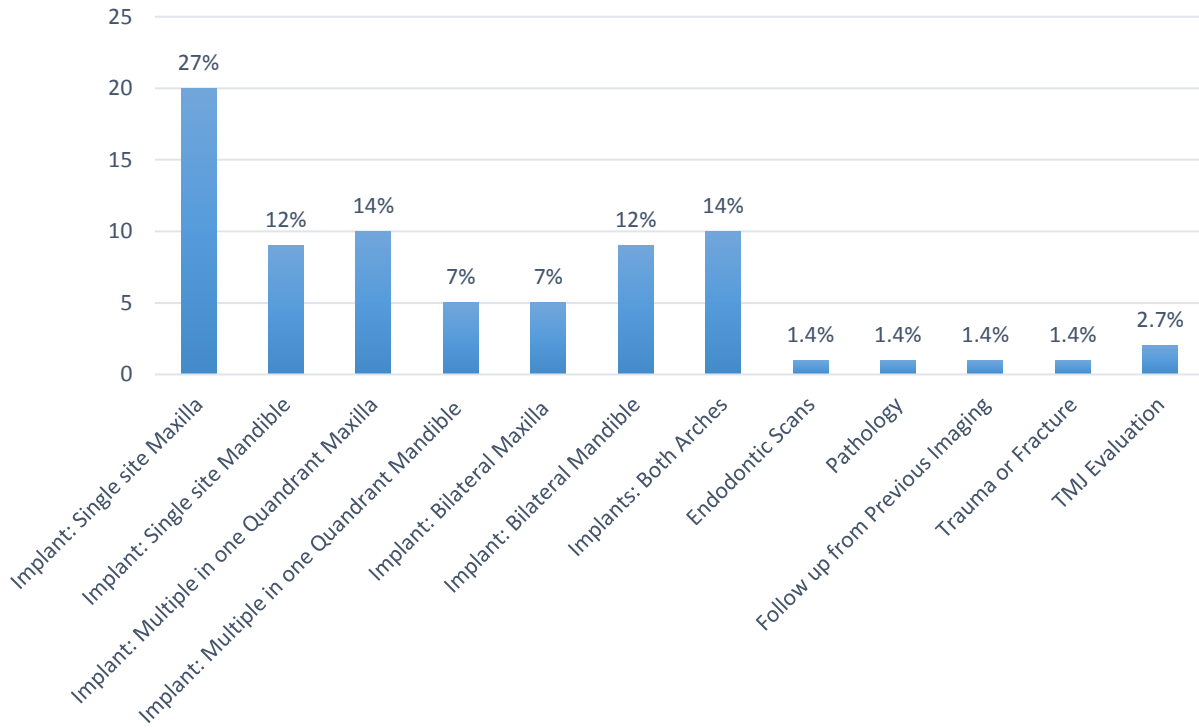
The most common indication for CBCT referral from AEGD residents was a single site in the maxilla, although less dramatically skewed than the implant distribution for periodontics residents. Note that a small percentage of patients for TMJ evaluation, the only residency program to refer for a CBCT evaluation of the TMJ evaluation.

The distribution of CBCT field-of-views obtained for AEGD residents is shown in Figure 19.

**Figure 19:** Field-of-Views Obtained for AEGD Residents
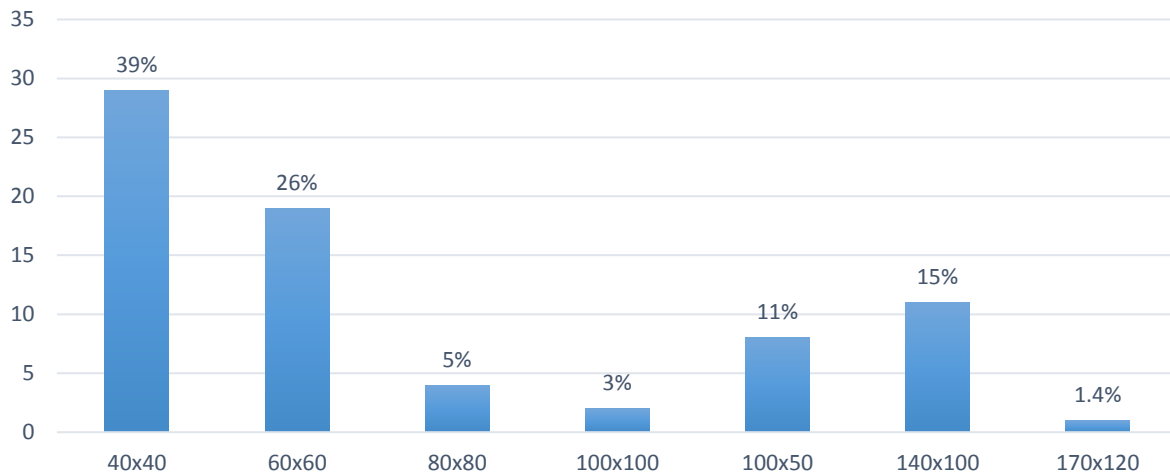
While 40x40 was the most common field-of-view, the second most common CBCT size obtained was a 60x60. Together, these two sizes accounted for over half of all CBCTs obtained by AEGD residents.

Predoctoral dental students only accounted for 19 scans or 3% of the overall referrals for CBCT acquisition. However, UCONN dental class of 2015 consisted of 35 students and the dental class of 2016 consisted of 44 students. When taking into consideration which class the predoctoral student belonged, 15 scans were referred from the class of 2015 and four scans were referred from the class of 2016. As a percentage, 43% of graduates from the class of 2015 were the referring provider for at least one patient during their fourth year of dental school. For the class of 2016, about 9% of students were the referring provider during their third year of dental school.

Implant treatment planning was almost exclusively the selection criteria referred from predoctoral students. However, one scan was referred for a suspected root fracture. Figure 20 shows the distribution of referrals from predoctoral students with implants separated by location.

**Figure 20**: CBCT Referrals from Predoctoral Students
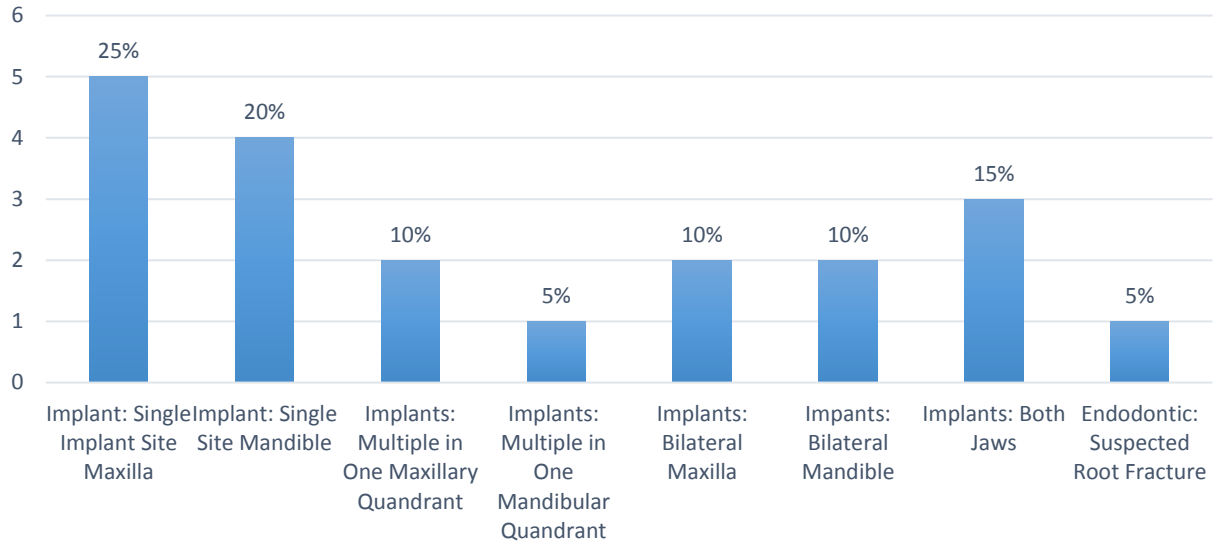
The CBCT referrals from predoctoral dental students was almost exclusively for implant treatment planning. Figure 21 shows that approximately half of the CBCT acquired for predoctoral students were a 40x40 size.

Figure 21: Field-of-Views Obtained for Predoctoral Students
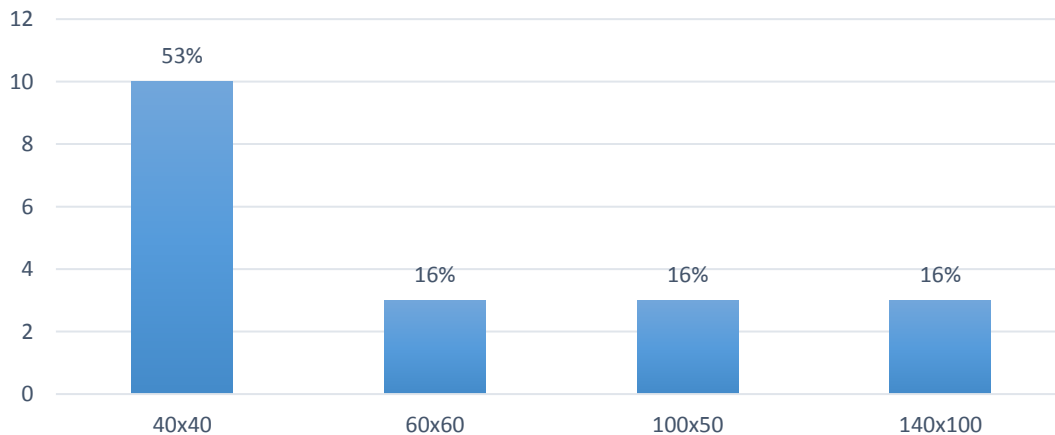
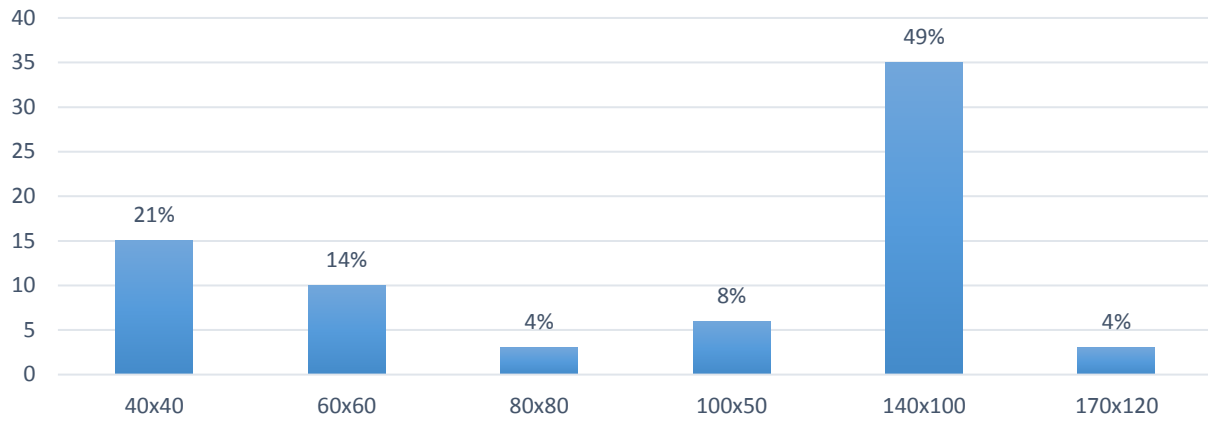OMFS residents and faculty combined were the fourth most common provider referring for CBCT scans.

Figure 22: Distribution of Selection Criteria from OMFS Faculty and Residents
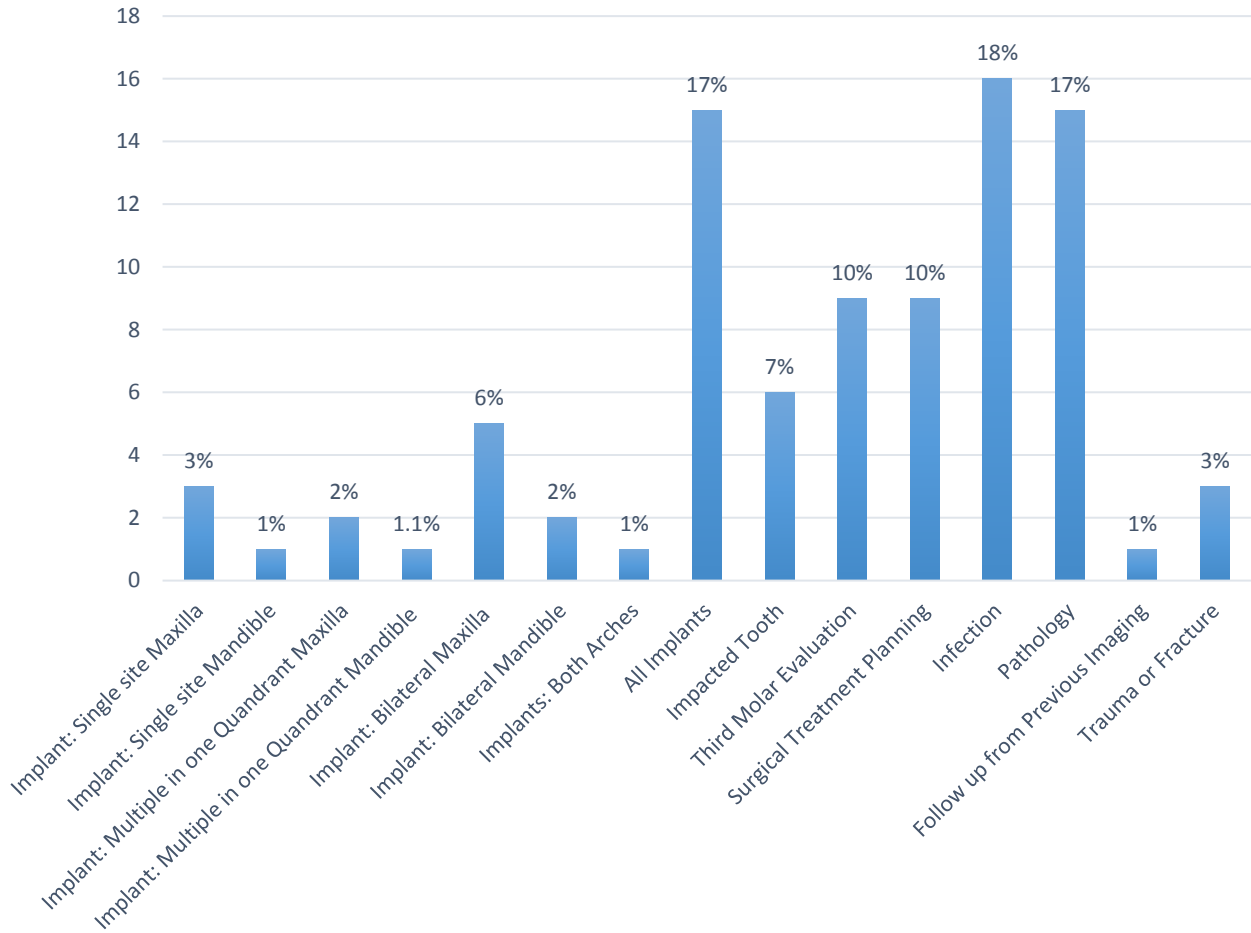
Unlike the previous providers mentioned earlier, implants were not the most common referrals from OMFS. Rather, infection accounted for the most common referral with implants and pathology scans having equal amount of referrals.

The distribution for field-of-views obtained for OMFS residents and faculty are shown in Figure 21.

Figure 21: Field-of-Views Obtained for OMFS Residents and Faculty

Nearly half of the scans obtained for OMFS residents and faculty were a large field of view, with the 40x40 size accounting for approximately 20% of all scans.

Orthodontic residents were the sixth most common specialist to refer for CBCT. Combined with the three CBCT referrals from orthodontic faculty, the distribution of CBCT referrals from the orthodontic department is shown in Figure 22.

Figure 22: Distribution of Selection Criteria from Orthodontic Faculty and Residents
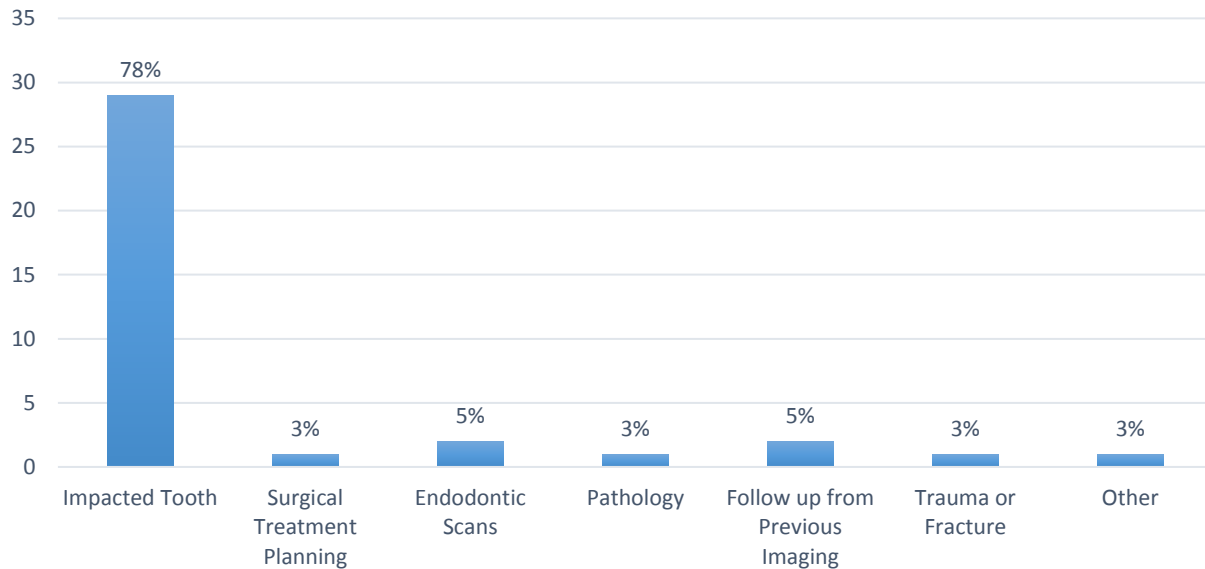

Of the scans not acquired for impacted teeth, the single surgical treatment planning case was for condylar asymmetry with surgery not specified. The endodontic scans were acquired for external root resorption and disturbances in root formation possibly from external root resorption, fracture, or dilaceration. A pathology scan was acquired for a radiolucent lesion with associated swelling. The follow up from previous imaging were for abnormalities noted on a lateral cephalometric and panoramic radiograph. One scan was acquired for trauma one year prior and the scan classified as "other" was for a cleft palate with no surgery indicated.

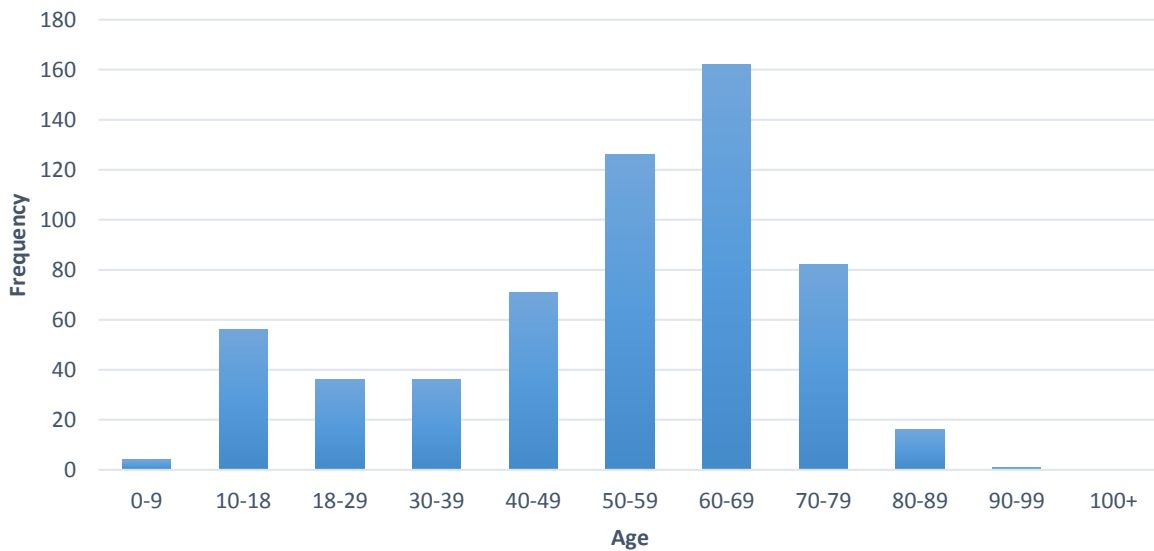<u>Patient Demographics</u>

The sample study population was 54% female, 46% male

Figure 23: Distribution of CBCT Acquisitions by Gender
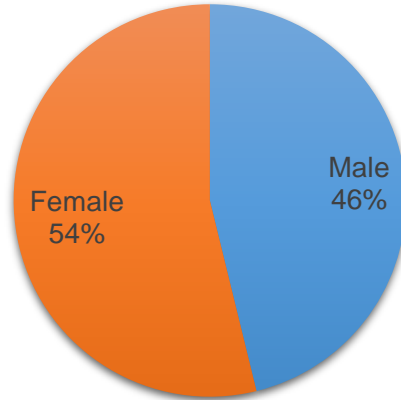
The average CBCT patient age was 52.3 years old. A histogram of the patients' ages is shown in Figure 24.

Figure 24: Patient's Age at Time of CBCT Acquisition

There were 60 scans of pediatric patients (age 18 or younger), representing approximately 10% of the total scans. The distribution for the providers for pediatric patients for CBCT is shown in Figure 25.

Figure 25: Distribution of Providers of Pediatric Patients for CBCT Scans
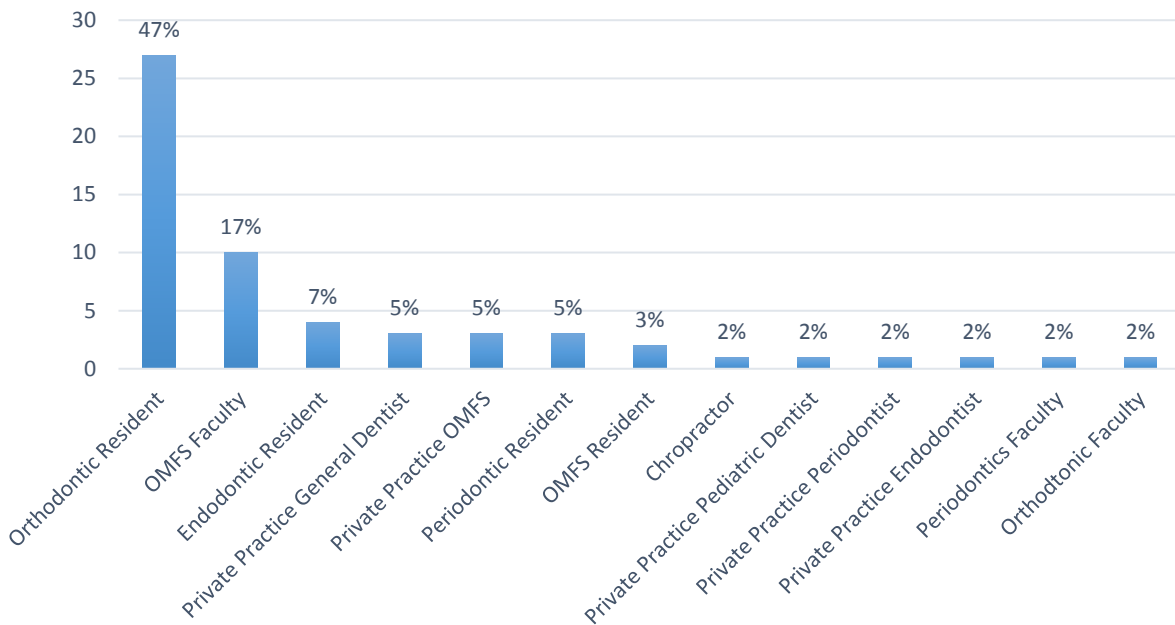
Figure 25 shows most common referring provider for pediatric patients was an orthodontic resident.

The selection criteria for the pediatric patient population is shown in Figure 26.

Figure 26: Selection Criteria of Pediatric Patients For CBCT Evaluation
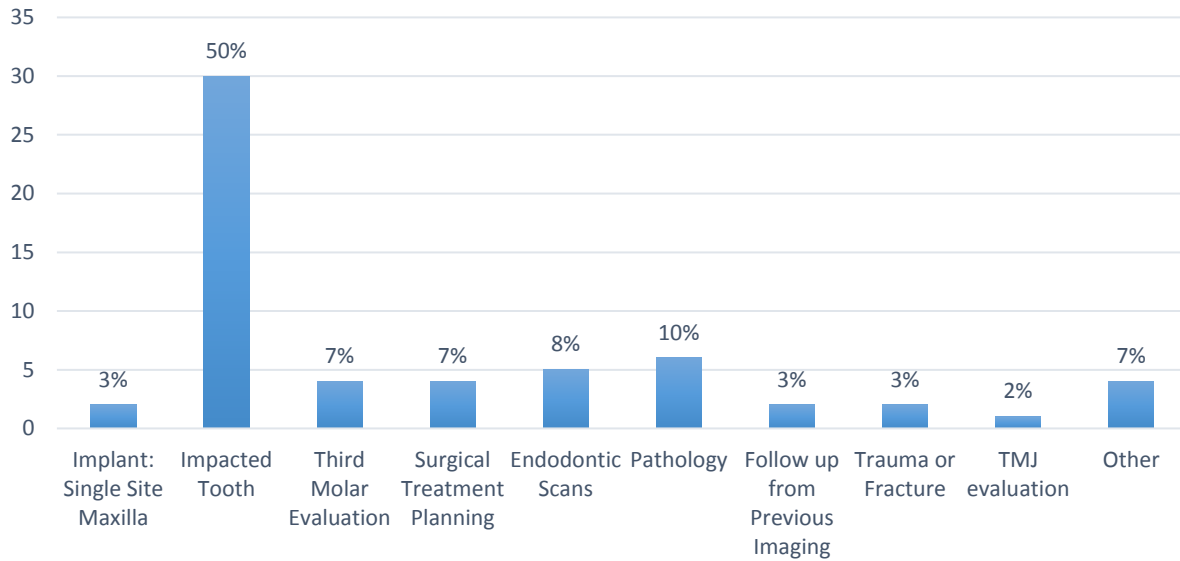
This shows the most common referring selection criteria for a pediatric patient was for an impacted tooth, account for approximately half of all pediatric referrals. Of note, pediatric patients were rarely referred for only for implants and when referred, it was always a single site in the maxilla.

The imaging needs of the pediatric patients can be compared to the imaging needs of young adults (ages 19-29), shown in Figure 27.

Figure 27: Selection Criteria of Patients Ages 19-29 For CBCT Evaluation
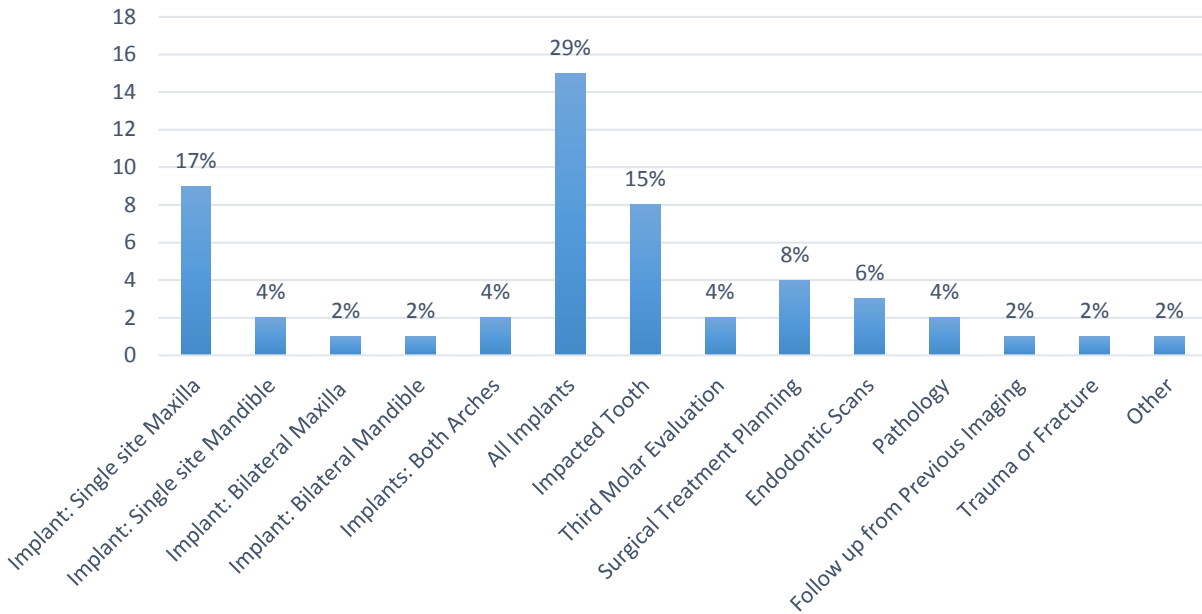
For the young adult population, implant treatment planning was the most common indication for referral for young adults with the most common site being a single site in the maxilla. Impacted tooth was the second most common reason for CBCT referral of young adults.

Comparatively, the imaging needs of all patients ages 30 or older are shown in Figure 28.

Figure 28: Distribution of Imaging Needs of Patients 30 Years and Older
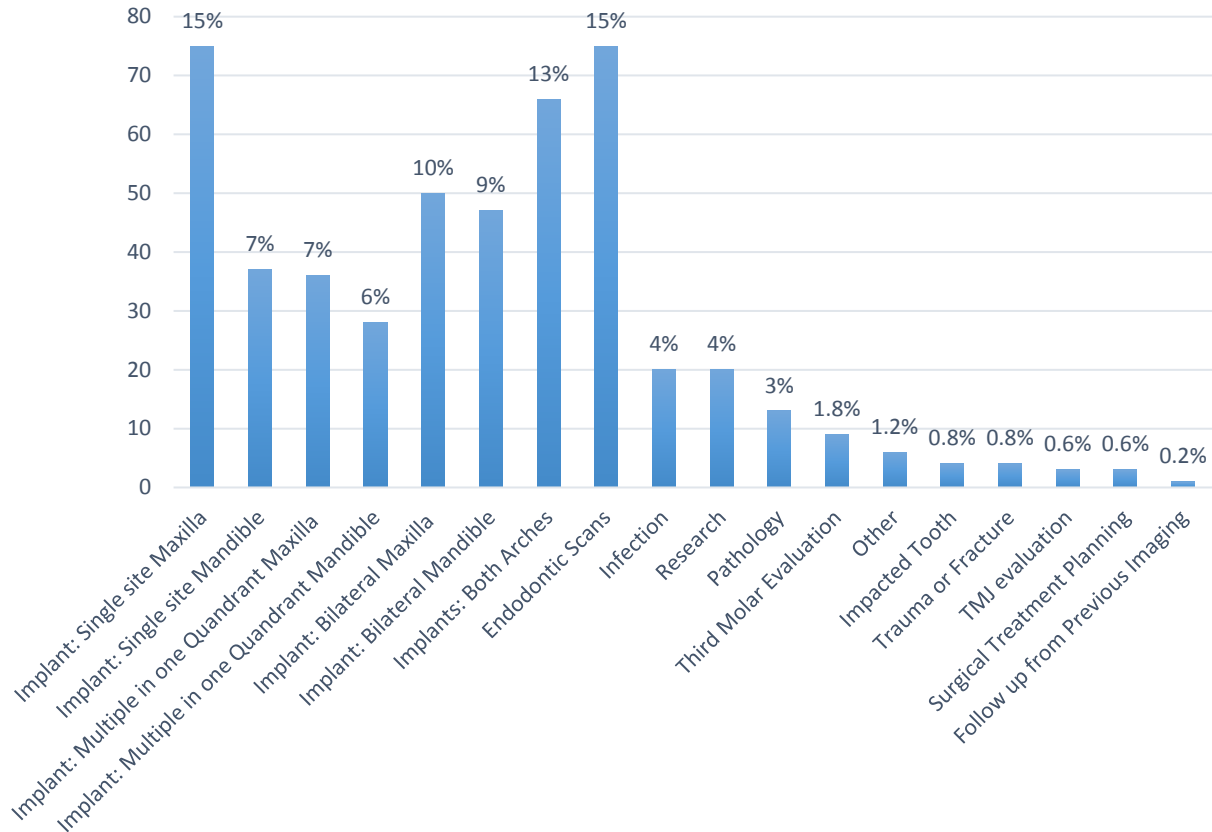
Implants were the most common selection criteria for this age demographic, with single site maxilla the most common site but closely followed by implant treatment planning of both arches. Endodontic scans were equally as common as implant treatment planning for a single site in the maxilla for patients over the age of 30.

A summary of the significant findings of this study are as follows:

- Eleven major categories of referral for CBCT were identified. Implants were the most common CBCT referral for all ages, with the single site maxilla the most common implant site.

- Endodontic scans were the second most common indication for CBCT referral. Of the endodontic scans, 11% were acquired intra-treatment and 6% were acquired post-treatment.

- The most common impacted tooth referred for CBCT evaluation was an impacted maxillary canine, accounting for 58% of all impacted tooth referrals.

- Approximately two-thirds of third molar evaluations involved a unilateral mandibular third molar only.

- As a percentage, 43% of graduates from the dental class of 2015 were the referring provider for at least one patient during their fourth year of dental school. For the dental class of 2016, about 9% of students were the referring provider during their third year of dental

- The average CBCT patient age was 52.3 years.

- Pediatric patients accounted for approximately 10% of the patients being seen for CBCT. Orthodontic residents accounted for nearly half of the providers for pediatric patients referred for CBCT.

- The most common indication for CBCT referral of a pediatric patient was for an impacted tooth, account for approximately 50% of pediatric referrals. Pediatric patients were rarely referred for only for implants and when referred, it was always a single site in the maxilla.

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DISCUSSION

The objective of this study was to obtain a recent profile of clinicians referring for CBCT evaluation, the indications why patients they are being referred, and the profile of a typical patient referred for CBCT.

This present study showed that periodontics residents were the specialist that referred for CBCT evaluation almost exclusively for implant treatment planning that usually involved a single site in the maxilla. The second most common provider referring for CBCT evaluation were prosthodontic residents referring for implant treatment planning involving both arches. The third most common provider were AEGD residents who often referred for implant treatment planning involving a single site in the maxilla.

The majority of the providers referring for CBCT at UCHC were providers that were internally located within the dental graduate specialty programs. However, 13% of all scans were from private practioners in the community. Of these, private practice endodontists were the most common external providers, followed by private practice periodontists.

Of the clinical indications why a patient was being referred for CBCT examinations, twelve major categories were identified. Of these categories, one category was for CBCT scans that were acquired as part of two studies being conducted during this time period, so called "research" scans. Research is part of any academic institution and the amount of research is almost certainly variable among academic institutions. "Research" would be an unlikely clinical indication from a private practioner.

There currently are no ADA guidelines on the prescription of CBCT. However, in 2012, the European Commission published detailed evidence-based guidelines on the use of CBCT.

In the absence of ADA guidelines, we can compare the observations made in this study to the guidelines published by the European Commission (EC)

According to the EC guidelines, prior to referring a patient for CBCT, the referring clinician must have a justification for the scan.[2] This was observed in our present study; all CBCT requisitions had some indication why the clinician was ordering the scan, with varying amounts of detail. Additionally, the EC guidelines says that when a dentist refers, he should include "adequate clinical information about the patient."[2] In regards to CBCT scans acquired for implant treatment planning, most providers only included the implant sites of interest. Sometimes, the providers included dates of extractions, if bone graft material had been placed, or if the teeth had originally been congenitally missing. However, inclusion of this patient history for implant scans was rare observed in our study; only 7 scans of the 392 implant scans provided histories such as the teeth were congenitally missing or the scan was being acquired post graft placement.

Currently, the requisition forms at UCHC have a section that says, "reason for scan/relevant clinical history;" this is often where providers select implants and list the implant sites. To increase the amount of patient history or relevant treatment rendered included with implant CBCT referrals, it might be beneficial to have the requisition forms with two separate lines for "reason for scan" and "relevant clinical history."

However, unlike the scans for implants, from the same requisition form with a single combined information line, scans referred for endodontic evaluation almost always included extensive patient histories, date of prior endodontic treatment, current clinical signs and symptoms, working diagnosis, proposed treatment, or combinations thereof. It is unclear if this is due to the need of supportive findings to diagnose odontogenic pain and odontogenic infections or if this is a feature unique to endodontists and endodontic residents.

Of the other CBCT indications identified in this study, the category of "infections" often included patient histories. However, these supplied histories were brief and not nearly as extensive as those included in endodontic requests. In regards to scans for ONJ, providers often included if the patient had a history of antiresorptives, presumably to aid in the diagnosis of medication-related osteonecrosis of the jaw (MRONJ), as MRONJ cannot be diagnosed in the absence of medication. The date of termination of antiresorptives or the diagnosis of an initial cancer was sometimes included. Inclusion of more elaborate patient histories would often aid in the diagnosis of complex infections.

This present study shows that the average patient referred for CBCT is a 53 year old referred for implant treatment planning. The patient's ages follow a normal distribution with a small secondary peak noted in pediatric patients 10-18 years old. Older patients (30+ years old) were typically referred for implant treatment planning. However, pediatric patients were most often referred for impacted teeth and surgical treatment planning; not surprisingly, pediatric patients were rarely referred for implant treatment planning.

In regards to temporary anchoring devices (TADs), the EC guidelines specify that CBCT is not normally indicated for planning for TADs in orthodontics. In our study sample, no CBCTs were acquired solely for TAD treatment planning. However, we classified our requisition forms based on the first selection criteria listed. There were two requisition forms where "TAD" was a secondary indication for CBCT referral. For both scans, the dominant reason listed was an impacted tooth. Of note, to the best of our knowledge, there were no scans acquired for routine orthodontic treatment planning, which is congruent with the recommendation made by the EC guidelines.[2]

For list of providers, it is interesting to note that only a single scan was requested by a private practice pediatric dentist and no scans were requested by a pediatric dental resident. However, pediatric patients made up approximately 10% of the overall patient population

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referred for CBCT evaluation. This disparity is likely reflective of a natural work flow hidden from the requisition forms whereby pediatric dental providers refer a patient for, as an example, an impacted tooth and it is the responsibility for the new dental provider, usually orthodontics or OMFS, to determine if evaluation with CBCT is indicated.

Predoctoral dental students only accounted for 19 scans or 3% of the overall referrals for CBCT acquisition. As a percentage, 43% of graduates from the class of 2015 were the referring provider for at least one patient during their fourth year of dental school. For the third year dental students, about 9% of third year dental students were the referring provider during their third year of dental school. The increase in predoctoral students being the requesting provider as their education progresses is a reflective of the utilization of CBCT in more advanced needs of the dental patient, namely single site implants. A predoctoral general dentistry student having experience with CBCT is a great addition to their clinical education, as they could possibly order more CBCTs in the future as part of the patient care a general dentist might provide. This current study demonstrates predoctoral students are actively referring for CBCT as part of their of clinical indications for CBCT imaging However, the disadvantages and limitations of CBCT are equally important and should be equally emphasized in the predoctoral dental curriculum.

Interestingly, there were two scans that were requested by specialists other than dentists: a chiropractor and a doctor of osteopathic medicine. This present study is only a single snapshot in time; additional studies are needed to establish if these non-dental providers are an anomaly or part of a growing future trend of increased consultations between dentists and other health care providers.

This present study examined all CBCT scans acquired at UCHC in a single year. These scans have been acquired for providers internally located within an academic institute and for providers externally located to UCHC, with UCHC acting as an imaging location. We have developed a profile of the types of providers that are utilizing CBCT most often and the clinical

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indications for why CBCT is being acquired. These scans represent what we believe to be a 100% inclusive sample of all CBCT acquisitions at UCHC. However, there are CBCT machines in private practice. Dentists and dental specialists can acquire their own CBCT scans independent of UCHC. It would be interesting to develop a profile of clinicians that are consulting oral and maxillofacial radiologists—possibly the oral and maxillofacial radiologists located at UCONN Health Center—and to compare the profiles of the scans being consulted on.

Currently, there is a large void in the literature addressing consultations patterns of oral and maxillofacial radiologists. At the time of this study, we believe the only study available regarding consultations on oral images was by Perschbacher et al.[6] The Perschbacher study evaluated consults on oral images, almost exclusively intraoral images, panoramic images, or combinations thereof, to oral radiologists in Ontario, Canada over a three year period.[6] However, our present study and the Perschbacher study are quite different and not directly comparable for several reasons. The Perschbacher study evaluated practioners who were freely consulting oral radiologists on oral images. Our study is evaluating who is ordering CBCT images rather than freely consulting on CBCT images. Additionally, the Perschbacher study evaluated the results of the consultation. Our present study has only evaluated the incoming CBCT referral information without examining the results of the CBCT scan. The Perschbacher study found that the majority of their consultations of oral images were from general dentists (58.9%), followed by oral surgeon (21.5%), and orthodontists (7.6%).[6] The Perschbacher study found that the majority of their consultations were on panoramic images (43.3%), followed by panoramic and intraoral images (28.4%).[6] Nonetheless, our study and the Perschbacher study both contribute to the types of images specialists are utilizing and help contribute to the void in the literature regarding consultations of oral radiologists. Future studies that examine the consultation patterns of CBCT by oral radiologists and the results of the consultations would be a better direct comparison to the Perschbacher study.

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This study is limited by being located at a single-site location within UCONN Health Center. The patterns of referrals for CBCT could in theory vary by location. To better develop a true pattern of referrals of dentists and dental specialists ordering CBCTs, this current profile would be strengthened by repeating this study at multiple locations, both in academia and at private practice imaging centers. In this way, a more complete profile of dentists and dental specialists that are ordering CBCTs and the clinical indications as to why they are ordering them could better be developed. Additionally, this study is a single calendar year. To better visualize the imaging trends over a period of time, this study should be repeated both at UCONN Health Center and at other imaging sites over the course of several consecutive years to see imaging trends vary over time and, if so, if there are contributing factors in the dental community that can explain any trends.

CONCLUSIONS

This study has clearly demonstrated that implant treatment planning is the main indication for CBCT referral for multiple dental specialists, including predoctoral students in an academic dentistry seeting. However, the patterns of edentulism the specialist is planning for varies from single site edentulism in the graduate periodontics and AEGD residency programs to overwhelmingly maxillary and mandibular edentulism in the graduate prosthodontic program. This pattern of edentulism is reflected in the size the CBCT being taken and provided to the requesting provider.

This study is greatly limited by a single site location. However, I believe this is the only study of its kind that has developed a profile of clinicians that are utilizing CBCT and the distribution of clinical indications CBCT is being utilized. Oral and maxillofacial radiologists should be familiar with the types of scans their referring providers are requesting and the type of information the requesting provider is hoping to obtain from a CBCT scan so radiologists can write the most useful report possible. Additionally, when developing continuing education courses, this study demonstrates the types of specialists that would most benefit from radiology courses tailored to their imaging needs. For example, this study shows that while pediatric patients are being imaged with CBCT, their requesting provider is almost never a pediatric dentist. Therefore, a continuing education course regarding the imaging needs of pediatric patients would be best presented to orthodontists or oral and maxillofacial radiologists in addition to pediatric dentists.

Additionally, this study provides valuable information to the radiologist about their requesting providers. While some clinicians supply additional selection criteria i.e. evaluation of existing implant adjacent to the area of interest, many clinicians do not. However, the exclusion of additional selection criteria can underemphasize the amount of information the requesting

provider is expecting or can lead to inadequate field-of-views. This can set low expectations when referring to and consulting with oral and maxillofacial radiologists. I believe oral and maxillofacial radiologists should continue to interact with the other dental specialties in the years beyond that of an academic setting. This would help the radiologist understand the types of information the requesting provider is anticipating and any additional information the radiologist could provide when specified.

Although the two scans requested by a chiropractor and a doctor of osteopathic medicine represent such a small percentage of the overall sample, the possibility of interacting with specialists other than dentists is a potential area of consultations the oral and maxillofacial radiologist could consider, particularly as CBCT potentially becomes more popular in the years to come.

FUTURE DIRECTIONS

This present study demonstrates the CBCT acquisition patterns of dental specialists limited to the single site location of UCONN Health Center. Repeating this study at multiple sites, both in academia and in private practice imaging centers, would better develop a true profile of CBCT acquisition patterns.

While study present study demonstrates the acquisition patterns, it would be interesting to compare the consultation patterns of CBCTs by dental specialists, the clinical concerns for the consultations, and how the consultation patterns differ from the acquisition patterns. This would help identify any large discrepancies of scans that are potentially being acquired but not being consulted with an oral and maxillofacial radiologist.

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