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Analysis of Referral Patterns to a Dento-Maxillofacial Radiologist from Dental Practitioners

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Abstract

Background: Intra-oral radiography is ubiquitous in dentistry and practitioners are increasingly using extra-oral radiography in everyday practice. Practitioners may encounter findings on radiographs that they are unfamiliar with and are unsure of the clinical significance. This retrospective study aimed to ascertain the radiographic presentations which were more likely to prompt these clinicians to seek an opinion from a Dento-maxillofacial radiologist (DMFR) and the most common pathologies referred.

Methods: Radiology reports written over a 10-year period were obtained from a DMFR based at an Australian learning institution. These reports were de-identified and assessed for referrer details, radiographic features as well as the radiographic opinion provided by the DMFR. Intra-examiner agreement was undertaken using a random and blinded sample of 20 cases with a 1 month delay between radiographic assessments.

Results: There were 311 cases that fit the inclusion criteria for the study. The most frequently referred images were panoramic radiographs (PRs) and cone beam computer tomography (CBCT) datasets. Almost half of all referrals were in relation to a radiopacity which is in keeping with existing research; however general dental practitioners (GDPs) were more likely to refer opacities compared to dental specialists (DSs) ($P<0.01$). There was no appreciable difference between the proportion of normal cases referred and those containing abnormalities; however, CBCTs were 2.5 times more likely to contain abnormalities (CI: 1.3, 4.4, $P< 0.01$). Our analysis of intra-examiner agreement confirmed 100% agreement between the two time points ($n = 20$, $\kappa = 1.00$), using diagnoses of normal and abnormal.

Conclusion: A high proportion of the cases digitally referred for a radiology opinion were normal or could be monitored. Obtaining an opinion from a DMFR may assist clinicians in reducing unnecessary physical referrals of their patients when a region of interest is identified and a clinician is unsure of the associated significance.

Keywords: Radiology; Cone-beam computed tomography; Panoramic radiography; Dento-maxillofacial radiologist

List of abbreviations: CBCT: Cone Beam Computer Tomography; DMFR: Dento-Maxillofacial Radiologist; DS: Dental Specialist; EO: Extraoral; GDP: General Dental Practitioner; IF: Incidental Finding; IO: Intraoral; PR: Panoramic Radiograph; PA: Periapical Radiograph

Introduction

Radiographic assessment is common place in both specialist and general dental practice as part of routine dental examination, to facilitate treatment planning or for assessment of a region of interest. Intraoral (IO) radiographs are essential to daily dental practice and there is increased uptake of privately owned extraoral (EO) imaging machines capable of creating panoramic radiographs (PRs) and cone beam computer tomography (CBCT) datasets [1].

Any form of imaging can contain abnormalities relating to a region of interest based on clinical findings, such as swelling or pain, however current literature indicates that EO imaging can also have a high proportion of incidental findings (IFs) [2]. IFs are defined as 'any findings detected by a diagnostic imaging modality that are unrelated to the clinical indication for the imaging being performed' and are common in EO imaging [3]. EO imaging taken in medical radiology practices through referral have an accompanying radiology report that offers commentary on the entirety of the imaging including any IFs which may be present. Privately taken IO and EO imaging are predominantly interpreted by the clinician capturing them and as such general dental

practitioners (GDPs) and other dental specialists (DSs) are frequently the only practitioners who review these images. It is widely acknowledged in Australia that the clinician capturing these images is responsible for reviewing the imaging in its entirety, not just the region of interest [4,5]. When an IF or area of suspected abnormality is detected, the clinician must distinguish between potential artefact, what is normal and what is abnormal.

However, interpretation of radiographic examinations such as PRs is complicated by the high incidence of positioning errors which can significantly impact the diagnostic quality of the image [6-9] by causing an increase in superimposition, distortions and ghost images [10]. PR interpretation is also highly dependent on practitioner experience with GDPs historically displaying low scores for knowledge of panoramic anatomy and for detection of pathology [11-13]. Thorough interpretation of CBCT datasets requires advanced knowledge of anatomy and pathology [14,15] which is not provided in most undergraduate dental courses in Australia at this point in time. In addition, there is currently no national consensus regarding the level of proficiency and training required prior to using a CBCT machine and interpreting CBCT datasets [16-23].

These limitations in interpretation and identification of potential pathology in PR and CBCT datasets can lead to unnecessary referral if artefact is mistaken for pathology as well as the associated patient harm [24], or worse, pathology which has been missed entirely.

Some GDPs choose to supplement their initial interpretation of IO and EO imaging with referral to a Dento-maxillofacial radiologist (DMFR) to provide specialised interpretation of any regions of interest detected and advice as to whether further referral is needed and which specialist would be most appropriate. This could reduce the risk of unnecessary referrals and direct the patient to the most appropriate form of specialist care.

However, there is currently limited information regarding the types of lesions and radiographic presentations that are more likely to prompt GDPs and DSs to seek referral to a DMFR. Experienced DMFRs could offer anecdotal opinions regarding referral patterns, but there are currently only two published studies in this area of research which were based in Canada and the United Kingdom [25,26]. This retrospective study aims to address the lack of published data in this field in Australia. We also aim to ascertain: radiographic presentations which prompt clinicians to request a DMFR opinion; the most common pathologies referred; the types of images referred; the quality of clinical details provided and changes in the patterns of referrals if there are any. The authors hypothesised that a significant proportion of cases referred for assessment would represent normal variations in anatomy or projectional errors and that the majority of cases referred would relate to the presence of an opacity.

Methods

This retrospective study was conducted in accordance with Human Ethics Guidelines approved by the University of Queensland (project no. 1629). This study involved assessment of consecutive radiology reports written by a DMFR, who is a clinical academic at the University of Queensland, in response to referral letters from private clinicians. Referral letters for routine radiographic assessment or screening where there was no obvious region of concern detected by the referrer were not included in this study.

The criterion for inclusion was the availability of the following information: a radiographic region of interest; a description of the radiographic presentation of the region of interest by the reporting DMFR and an opinion on what the region of interest may represent. Cases with insufficient referrer information and inadequate clinical descriptions from referrers were not excluded because these parameters were measured as part of this study. Cases that were dealt with via telephone were also excluded from the study. After applying the inclusion criteria to over 500 referral letters written over a 10-year period, extending from June 2007 to November 2017, and 287 reports were selected. No actual radiographic images were reviewed as part of this study.

The DMFR sourced the year of graduation and qualifications of the referring clinician from publicly available records on the Australian Health Practitioner Regulation Authority website. The DMFR allocated all referrers a de-identified reference number which was tracked in a Microsoft Excel (Microsoft Windows, NM, USA) spreadsheet. Every case was allocated a case number and all patient identifying information was removed by the DMFR, leaving only patient gender and age. The de-identified reports were then analysed by the principal investigator (YL) who recorded further referrer and patient details relating to the date the referral was received; the film type submitted; the reason a referral was requested and the quality of the referrer details as well as the clinical details/patient history provided.

Radiographic features recorded specific to the region of interest included the location, an approximate size (localised, multifocal, widespread or not applicable (N/A)), radio-density (radiolucent, radiopaque, mixed density lesions or N/A), radiographic border distinctness (well-defined, poorly-defined or N/A) and the presence of an effect on surrounding structures (displacement of teeth, the inferior dental canal or resorption, etc.).

The opinion of the DMFR in relation to the region of interest was first broadly categorised into 'normal' or 'abnormal' and then further sub-classified based on previous research [25]. Areas of interest categorised as 'normal' were sub-classified into the following groups: normal anatomy; variation of normal anatomy; healing; artefact/projectional or a negative examination where the reason for a patient's presenting complaint could not be ascertained based on radiographic examination. Areas of interest categorised as 'abnormal' were sub-classified into the following groups: bone dysplasia; cyst/pseudo-cyst; inflammation/infection;

soft tissue calcification; developmental abnormality; benign neoplasm; TMJ abnormality; suspected malignant neoplasm; trauma or systemic disease.

Quantitative data were analysed using the statistical features of IBM SPSS 21 (SPSS Inc., Chicago, IL, USA). Fisher's exact test was performed to determine if any referrer variables were associated with the radiographic findings. A P value of <0.05 was considered significant. The proportion of practitioner referrals based on qualifications, years of experience, film type and specific radiographic features were also assessed to ascertain the most common circumstances for referral. Intra-examiner reliability was assessed using a random and blinded sample of 20 cases ranging from PAs to CBCTs. A one-month interval was allowed between radiographic assessment of the cases.

Results

Referrals were received from 93 clinicians comprising of 69 GDPs and 24 DSs as seen in Table 1. There were an additional 17 clinicians who provided insufficient information to ascertain the nature of their qualifications. The 10 most prolific referrers were all GDPs with between 5-15 years of clinical experience; the most experienced referrer in this subgroup had 35 years of experience. All 24 specialists referred less than five cases with 20 referring only one or two cases.

Practitioner type	No. of referring practitioners (n = 120)	Proportion (%)
General practitioner	69	62.7
Orthodontists	9	8.2
Periodontists	7	6.4
Prosthodontists	4	3.6
Oral Maxillofacial Surgeon	2	1.8
Endodontists	1	0.9
Dento-maxillofacial Radiologist	1	0.9
Did not specify	17	15.5

Table 1: Distribution of referring practitioners by practitioner type (total n=110)

The 287 reports written by the DMFR offered radiographic opinions on 311 referred cases as 22 of the referral letters were accompanied by multiple images (Table 2). The most commonly referred imaging portfolio was a periapical radiograph (PA) with a follow up PR most likely because a suspected abnormality was detected and investigated further by the referring clinician. There was one case of an incisive canal cyst which was referred by a GDP in a portfolio containing a PA, PR and subsequently taken CBCT all of which were taken to examine the incisive canal region.

Type of radiograph/scan	No. of cases (n=311)	Proportion (%)
Extra-oral imaging		
Panoramic radiograph	220	70.7
Lateral Cephalometric	3	1
Waters View	1	0.3
Cone beam computer Tomography	57	18.3
Medical Computer Tomography	4	1.2
Intra-oral radiograph		
Periapical	25	8
Bitewing	1	0.3

Table 2: Distribution of cases by film type submitted (total n=311)

The number of reports received increased significantly over the 10-year study period. Only four referrals were received in 2007 however by 2017 the number of referrals peaked at 111. In approximately 12% of referrals received the DMFR was provided with either insufficient or no clinical information from the referrer to aid in radiographic assessment.

The IO images referred comprised of 26 IO radiographs only one of which was a bitewing examination referred by a GDP with three years of experience for suspected internal resorption which later returned a 'normal' DMFR opinion. Only six of the referred PAs were referred individually, the remaining 19 were all referred as part of a portfolio of available x-rays.

The EO imaging referred included 220 PRs, 57 CBCTs, three lateral cephalometric radiographs and one occipito-mental radiograph. Of particular interest was the referral of four medical computer tomography datasets with what the referrers considered 'insufficient detail' regarding the regions of interest in the accompanying radiology reports written by medical radiologists. In one such case

involving a 6-year-old child the radiology report provided by the medical radiologist did not acknowledge the presence of multiple supernumerary teeth which was of particular concern for the referring dentist.

The majority of referred cases (83%) were for localised regions of interest while, 11.9% were for wide spread areas of interest. Almost half of the referrals (45.7%) were for suspected opacities, 28% were for suspected radiolucencies and 7.7% represented mixed density regions. GDPs were more likely to refer opacities compared to dental specialists DSs ($P<0.01$). Over half of referred cases (59.5%) had sharp borders and 23.5% had diffuse borders.

Only 27% of regions of interest caused an effect on adjacent structures. The most commonly observed effects on adjacent structures were: thinning of bony cortices; reactive mucosal thickening in the adjacent maxillary sinus; thickening of the periodontal ligament space; narrowing/displacement of the inferior dental canal; root resorption and the presence of a draining sinus.

Our analysis of intra-examiner agreement confirmed 100% agreement between the two time points ($n = 20$, $\kappa = 1.00$), using diagnoses of normal and abnormal. Using the previously published classification, the DMFR opinions in the current study were broadly classified into 161 abnormal diagnoses and 150 normal diagnoses as seen in Tables 3 and 4. The most common normal diagnoses were: variations of normal, normal anatomy, projectional/artefact, negative examination and healing. The most common abnormal diagnoses were: soft tissue calcification, inflammation/infection, cyst/pseudocyst, temporomandibular joint abnormalities and developmental abnormality. There was no statistical difference between the proportions of normal or abnormal cases referred; however, CBCTs were 2.5 times more likely to contain abnormalities (CI: 1.3, 4.4, $P< 0.01$).

Diagnostic category	Examples	Proportion (n = 150) n (%)
Variation of normal anatomy	Idiopathic sclerosis, enostosis, bone island, lingual salivary depression, mandibular pararadicular third molar radiolucency	80 (53.3)
Normal anatomy	Submandibular fossa, mental depression, pterygoid fovea, hyoid bone, epiglottis, sigmoid notch, normal sinus anatomy	33 (22)
Negative examination	No radiographic evidence or explanation of symptoms	16 (10.7)
Artifact/Projectional	Beam hardening, projection artefact, summation effect	13 (8.7)
Healing	Post extraction healing, fibrous healing defect, previous trauma	8 (5.3)

Table 3: Distribution of cases interpreted as normal by diagnostic category (total n=150)

Diagnostic category	Examples	Proportion (n=161) n (%)
Soft tissue calcification	Sialoliths, atherosclerosis, ossification of styloid ligaments, tonsilloliths, lymph node calcifications, antroliths	40 (24.9)
Inflammation/infection	Inflammatory apical pathology, reactive mucosal thickening, condensing osteitis, reactive hypercementosis, fungal sinusitis, acute sinusitis	34 (21.1)
Cyst/ pseudocyst	Mucous retention cyst, incisive canal cyst, residual inflammatory cyst, dentigerous cyst, odontogenic keratocyst, simple bone cyst.	28 (17.4)
Temporomandibular joint abnormalities	Degenerative joint disease, erosive arthropathy, remodelling secondary to previous trauma, synovial chondromatosis	18 (11.2)
Developmental abnormality	Supernumerary teeth, lateral incisor invaginations, macrodont teeth	12 (7.5)
Bone dysplasia	Cemento-osseous dysplasia, fibrous dysplasia	11 (6.8)
Benign neoplasm	Odontome, ameloblastoma, osteoma, central ossifying fibroma	7 (4.3)

Diagnostic category	Examples	Proportion (n=161) n (%)
Trauma	Asymmetry of mandibular condyle due to previous trauma, root fractures, oroantral communication	7 (4.3)
Suspicious for malignancy	Metastatic ovarian cancer, metastatic disease	4 (2.5)

Table 4: Distribution of cases interpreted as abnormal by diagnostic category (total n=161)

Intra-examiner assessment revealed that 100% of cases (n = 20, κ = 1.00) were in agreement for the broad classification into either 'normal' or 'abnormal' diagnoses as well as the further sub-classifications discussed previously. There was one case out of 20 where the radiology opinion changed from a bone island to an enostosis; however this did not affect the sub-classification from 'variation of normal anatomy' or the proposed management of the entity.

Discussion

Clinical details

This study was the first to assess the quality of referral details that DMFRs receive and offer commentary on the importance of providing adequate clinical information. Anecdotal opinions from other DMFRs confirm that reporting on imaging with inadequate clinical information can be challenging as the radiologist is unaware of the perceived concern from the perspective of the referring clinician. In addition, if the region of concern is not obvious, for example if it is normal anatomy to a radiologist as was the case in 27 instances in this study, the referrer may receive a report they consider unsatisfactory.

Of concern in the current study was the finding that in 22 cases the DMFR was provided with only a CD with the imaging in question, a business card from the referrer and a brief thank you note with no other clinical information. In a further 16 cases the DMFR was provided with insufficient clinical information and examples of this included referrers commenting that the patient had a history of pain or neuralgia but not specifying the exact region this pertained to or mentioning the presence of an 'opacity' when there were multiple opacities present and it was unclear which was of concern to the referrer. Fortunately in 87.7% of cases sufficient clinical information was provided although these details were predominantly in reference to radiographic signs such as the presence of opacity and, while this is helps direct the radiologist to the region of concern for the referrer, it does not provide them with any new or additional information.

Clinicians may benefit from informing a DMFR of symptoms relating to pain, tooth vitality testing or swelling in addition to the location of a region of interest as these clinical signs and symptoms may not be apparent radiographically and will help guide the DMFR in providing a satisfactory, detailed report.

Referral patterns

The findings with regards to the progressive increase in the number of reports received over the study period were in keeping with the findings of Dave *et al.* who analysed referral patterns to a DFMR in a public dental hospital in the United Kingdom and similarly found that the demand for the DMFR reporting service increased in time [26]. Referral patterns were also evident in the portfolios referred during the duration of the study with the majority of multiple image portfolios referred in the final two years of the study. This pattern may coincide with an increased awareness of the benefits of referring all relevant images to a DMFR as their reports often comment that 'comparison with previous imaging would be of value' in assessing some regions of interest. These referrers, many of whom had referred cases previously, may have realised that providing all relevant imaging initially would result in a more detailed final report. The increase in the number of referrals with time is also in keeping with the findings of Zhang *et al.* that the number of x-rays machines correlates strongly with the number of dentists per capita [1] and the number of practicing dentists increased during the study period [27,28].

Patterns were also evident in the distribution of referrals in relation to individual referrers. There were 83 clinicians who referred between one to five cases and a further five clinicians referred between six and eight cases; therefore 61.8% of private cases were referred by 94.6% of referrers. The remaining five clinicians referred a total of 116 cases, the majority of which were PRs and CBCTs, of which one clinician referred 60 cases accounting for one fifth of all the cases analysed in this study. Previous research has demonstrated that the undergraduate teaching institute attended and level of experience have a significant influence on PR interpretation skill and as mentioned previously CBCT interpretation is being taught to varying degrees in Australian undergraduate institutions [11-13,29]. As such, it is understandable that there are significant variations in the distribution of referrals with some clinicians seldom referring imaging and others appearing to refer most of the EO imaging they take. The reasoning behind this treatment rationale may relate to the referring clinician's concerns regarding their skillset in radiological interpretation and the presumed risk of them 'missing something' which is likely in keeping with the referral patterns seen in other dental specialities.

The findings noted in relation to radiodensity of regions of interest confirmed the author's anecdotal observations and are in

keeping with existing literature that dental clinicians identify radiopacities with greater accuracy than radiolucencies [30] and refer these cases more frequently [25]. In the current study GDPs were also more likely to refer radiopacities when compared to DSs (P<0.01) who referred cases displaying a wider variety of radiodensities. Opacities are by no means the most common regions of interest seen by DMFRs working in large medical imaging clinics reporting over 300 cases per day, which supports the theory that the skewed referral pattern observed in the current study may be due to these regions being more obvious to detect when compared to radiolucent or mixed density regions of interest. The same observation could be made of regions of interest associated with sharp borders, as seen in 59.5% of cases reviewed in this study, because this is also not representative of the spectrum of cases seen by DMFRs in private practice. This is of concern as the most significant of pathologies, malignancy, often presents as a radiolucency with diffuse or ragged borders [31] and the trends observed in the current study indicate that there is a chance these areas could be missed as they are less obvious to GDPs and DSs.

Regions of interest

PRs are prone to significant superimposition and ghost imaging and when a positioning error is present, which research shows is quite common, these interpretational challenges are multiplied [6-10]. It is therefore not surprising that PRs represented 70.7% of all referrals and the majority of PR referrals were in reference to regions most prone to superimposition and ghost imaging. The mandibular rami, condyle and posterior body of mandible including the alveolus and apical regions of the posterior teeth in PRs were the primary regions of interest in 39% of all referrals in this study. The next most commonly referred region was the neck and areas posterior to the rami in PRs including the cervical spine and this accounted for 11% of referrals. CBCTs represented 18.3% of all referrals in this study and 49% of all CBCT referrals were in relation to the dentoalveolar complex with the most common diagnoses being inflammatory pathology, bone dysplasia and normal variants respectively. The remaining 51% of CBCT referrals were for IFs in extragnathic regions with diagnoses ranging from sinus pathology to metastatic disease.

Diagnoses

McNab *et al.* showed that undergraduate dental students and GDPs displayed low scores for identification of normal anatomy or variations of normal and these findings were echoed in the current study [11]. Similarly to the findings of Perschbacher *et al.* [25] almost half of all referrals received in this study, 48.2%, were for regions of interest a DMFR designated as 'normal'. Dave and colleagues also found that entities later diagnosed by a DMFR as 'normal anatomy' were the most commonly referred diagnostic category however they did not follow the categorisation used by Perschbacher *et al*. which was adopted for the current study [26].

Eighty cases in this group were for variations of normal anatomy as seen in Table 3 and an additional 33 referrals were for normal anatomy such as the submandibular fossa or the pterygoid fovea. In several of these cases the referrer did not suspect that the 'cystic lesions' or 'bilateral pathology' they observed may represent normal anatomy or variants in anatomy. Quite often additional imaging was undertaken, usually a CBCT or PR in the clinician's private practice, which the DMFR retrospectively considered unnecessary and often failed to assist the referrer in reaching the correct diagnosis. Dave and colleagues also found in their study that a proportion of requests from GDPs and DSs for further CBCT imaging of regions of interest referred for a DMFR opinion were determined to be unnecessary [26]. Of the 13 cases which represented artefact or projectional issues only one referrer suspected this and suggested 'artefact' as a possible diagnosis; several referrers expressed 'concern' about the radiographic appearance or suspected 'significant pathology' which was confirmed as superimposition of the airway in a PR.

Conveying these sentiments to a patient can cause significant harm and stress [24] which are of particular concern if these provisional diagnoses are incorrect. As such it is fortunate that in 150 cases in the current study the referrers chose to consult a DMFR first before informing the patient of their concerns.

Of the 161 cases which represented 'abnormality' there were four cases, two CBCTs and two PRs, which a DFMR believed were highly suspicious for malignancy and required further imaging or biopsy. Three of the four referrers frequently referred imaging to a DMFR and two were amongst the most prolific utilisers of this service. Therefore it is understandable they may have treated these particular regions of interest in a routine manner and relied heavily on the outcome of the DMFR opinion to guide their patient management. The authors propose that the fourth case, sent by a GDP with no history of utilising a DMFR service, would otherwise have been sent to a maxillofacial surgeon for appropriate management.

The distribution of the total number of normal or abnormal cases received in this study was almost equal as seen in Tables 3 and 4. This trend was mirrored when the cases were subcategorised into referrals received from GDPs and DSs. DSs referred 23 normal cases and 19 abnormal cases while GDPS referred 129 abnormal cases and 120 normal cases. There was no appreciable difference between the proportion of normal and abnormal cases referred from either GDPs or DSs indicating that both groups displayed similar skillsets in radiographic interpretation. However, regions of interest detected by GDPs and DSs in CBCT datasets were 2.5 times more likely to be abnormalities when compared to similar regions of interest detected in PRs (CI: 1.3, 4.4, P<0.01).

DMFRs are often pigeonholed as fulfilling the role of 'detecting pathology' in radiographs that referrers choose not to interpret themselves so they 'don't miss anything'. However, the high proportions of 'normal' cases referred from both GDP and DS groups further indicate that clinicians may also benefit from utilising a DMFR service to help prevent unnecessary referrals, as well as the associated patient harm and cost, by excluding pathology when a region of interest is detected by a referrer who is uncertain of a

diagnosis. Dave *et al.* have suggested that the cost benefit of a DMFR reporting service for dentists and patients requires further investigation and the authors of the current study support this recommendation [26].

There is some bias in the sampling undertaken in this study with GDPs referring almost six times as many cases as DSs. The disparity in the number of referrals received from GDPs and DSs is not representative of the much larger discrepancy in the ratio of registered DSs:GDPs in Australia which in 2017 was 11.5:1 [32]. The DSs observed in the current study maybe a subset of the specialist population who are more likely to utilise DMFR services and this sampling bias could be addressed by further research using additional data from more DMFRs Australia wide.

Conclusion

The majority of cases referred were for regions of interest detected as radiopacities, and PRs were the most commonly referred image type. There were almost equal proportions of cases categorised as normal or representing abnormality and there was no statistical difference between the proportions of referrals from GDPs and DSs. In addition to routine assessment of imaging, DMFRs can assist clinicians when a region of interest is detected and a clinician is unsure of the associated significance.

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