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Template & Guidelines for reporting on Cone Beam Computed Tomography scans: a review

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Abstract

The aim of this review is to know the proper way of viewing CBCT scan and to write a report in a systematic way. A radiographic report's goal is to provide a correct interpretation of images to aid in the diagnosis process and, where necessary, to suggest appropriate patient management. It is part of the patient's clinical records. This presentation explains the imaging chain involved in the cone beam computed tomography (CBCT) method, from reference through reporting on a CBCT scan. It offers guidance on what information is needed before & after a CBCT scan, as well as how to improve the viewing circumstances. Finally, it outlines a strategy for creating a methodical, thorough, and customized CBCT radiographic report. It is aimed at endodontists, implantologist, periodontist, orthodontist, clinicians, and radiologists reporting on CBCT scans of the dentoalveolar region. The quality, accuracy, and use of a report are subject to medicolegal scrutiny so such report should be perfect and clear.

Keywords: CBCT, CBCT Report, CBCT viewing condition.

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1. Introduction

Over the last three decades, there has been a slow increase in the use of CBCT in all departments of dental specialty with a continuing rise in the number of clinical studies demonstrating the benefit of CBCT on diagnosis, treatment planning, decision-making and reducing practitioner stress levels. As in any disruptive technology introduced to a profession, the education lags far behind the technological advance. This is especially true of CBCT imaging. Unfortunately, there isn't a simple solution and there's no straightforward method for dentists to quickly refresh their knowledge. It takes time, effort, and sometimes even some direction to comprehend CBCT. Manufacturers, who were also quick to recognize the appeal of this technology, frequently fail to offer even the most fundamental training so that professionals do not unintentionally hurt patients. Reporting the findings in a CBCT volume is probably the most essential process in the total diagnostic evaluation of a patient, even if it is something as simple as implant planning. After reporting the findings, it is important to write a proper structured report in a systematic way, it requires a proper guideline for better understanding of the patient and prescribed doctor. This article throughs a light on how to view, what to view, where to view and to present it in a structured way for easy understanding of patient and prescribed doctor [1,2].

2.The imaging chain

The stages of imaging are referred to as the "imaging chain," which begins with the decision to capture an image and finishes with the reporting of the image. With intraoral radiography, for instance, the dentist typically serves as the referrer, practitioner, operator (radiographer), and operator (reporting). However, with CBCT, the tasks are typically not performed by the same person; rather, a team frequently participates in the imaging chain.. The various duties and procedures depend on the laws and regulations governing radiation safety in each nation. It is best practice to have the imaging chain well outlined, documented, and approved by all parties, especially when all of the functions are not performed at the same location. In order to create an actionable radiography report for narrow field-of-view cone beam computed tomography (CBCT) scans used for diagnosis and treatment, this article set out to first create the ideal viewing circumstances [3,4].

2.1. Viewing conditions

The ideal environment for viewing and reporting CBCT scans is a calm, dimly lit space with a diagnostic display system of the highest caliber (monitor). In comparison to properly calibrated medical monitors, the majority of "off the shelf" monitors perform less effectively in terms of diagnosis. Examining CBCT scans in a specialized reporting room allows for adequate adjustment of the lighting and viewing conditions (or in surgery before or after clinic). As a supplementary monitor, in-surgery monitors may be helpful for patient demonstration or for patient reference throughout the course of therapy [5,6,7]. The lighting and viewing conditions can be properly adjusted while examining CBCT scans in a designated reporting room (or in surgery before or after clinic). This offers the practitioner enough time to thoroughly evaluate all of the data and take into account provisional radiography diagnoses without worrying about being interrupted by the patient, who is understandably curious or concerned [8,9]. This offers the practitioner enough time to thoroughly evaluate all of the data and take into account provisional radiography diagnoses without worrying about being interrupted by the patient, who is understandably curious or concerned. The patient must be informed that the brief examination of the CBCT scan taking place in the operating room is simply a preliminary evaluation and that a diagnosis and treatment strategy can only be developed following a comprehensive evaluation [9,10].

2.2 Preliminary information

2.2a. Patient details

This information is crucial to ensuring that the right patient is assigned to the right scan. A minimum of one extra distinctive identifier, ideally more (like date of birth, address, or hospital number), should be provided in addition to the entire name. This is in the event that names are spelled differently or there are typographical problems when entered into a computer system (eg: Arvind, Aravind, Aravindh) [10]. This information is necessary to make sure that the right patient receives the right scan. In addition to full name, at least one other unique identifier (eg, date of birth, address, hospital number) should be used, preferably more. This is in case there are typographic errors when entered onto a computer system, or differences in spelling of names [10].

2.2b. Clinical details

In order to serve as a record of the treatment reasoning at the time of the scan and to give information to a third party in the event that the report is outsourced or a second opinion is requested, this section serves two main goals. If a CBCT scan is being referred for reporting, clinically pertinent information should also be included in the referral. This gives the reporter a "window" into the treatment plan and explains why the CBCT scan was performed. This should also contain any pertinent medical and dental history, such as a history of head and neck radiation therapy that may have exposed the jaws, the timing of a prior extraction where the site is healing slowly, dental trauma, or a tooth with a symptomatic endodontic treatment. Along with the scan, there should be a reason for choosing CBCT over different imaging modalities. The radiologist can adjust the report to the needs of the clinician with the help of this information. For instance, if the scan is being done to plan an implant, the report is likely to specify the locations of important anatomical structures and anatomical variations.[11]

2.2c. Radiography log

The following details should be recorded:

• The name of the operator

• Exposure parameters (eg 180/360° rotation, mA, kV, resolution)

• The anatomical region (eg lef posterior mandible, anterior maxilla etc)

• Grade of scan and any comments

CBCT grade 1 means **'acceptable'**, and grade 2 means **'unacceptable'**

'First scan grade 2 – patient moved during scan, scan aborted and retaken.

Second scan grade 1'

It should be noted that CBCT scans are graded differently to other dental radiographic imaging. Whatever maybe the grading it must to be mentioned and the reason for retake has to be specified.

Details of exposure parameters are essential to improve problem-solving when a diagnostically poor-quality scan has been taken. Furthermore, if future (follow-up) scans are required these exposure parameters may be modified to potentially improve image quality or replicated for comparison.

3. A Suggested Method for Scan Review

The adoption of proper reporting system within the dental profession that helps dentist and dental specialists review their CBCT volumes is fascinating. So that they themselves make sure that they examine each portion of the volume, the subsequent anatomic regions, once given, are invariably examined every time within the same fashion to see abnormal condition or occult pathology to report back to their referring purchasers. [12,13]

1) Paranasal sinuses
2) Nasal cavity
3) Airway
4) Cervical structures
5) TMJs
6) Dental findings
7) Other findings

3.1. Paranasal Sinuses

The paranasal sinuses are made up of the ethmoid air cell complex, the frontal, sphenoid bone, and maxillary sinuses. The majority of dentists are aware of potential inflammatory alterations in the maxillary sinuses. The maxillary sinuses frequently experience mucosal thickening, mucus retention phenomena (antral pseudocyst), and, less frequently, antroliths. The additional paranasal sinus areas are frequently affected when the inflammatory alterations in the maxillary sinus are severe. When considerable areas of the maxillary antra are affected, it is vital to take into account the probability of inflammatory alteration in the other paranasal regions. Even if only a portion of the maxillary antra is visible in the scan's restricted field of view (FOV), in some circumstances this may entail an instant referral to a primary care physician and/or an otolaryngologist for clinical and endoscopic assessment of all the paranasal sinuses (Figs. 1-2) [13,14].

However, any swelling within any of the paranasal sinuses should cause a clinician to be suspicious and should prompt making the proper referral:

- An increase or decrease in the size of the space's wall.
- Destruction of the room's bony wall.
- Any surrounding wall's thickening (hyperostosis)
- A sinus infection (major portions of multiple spaces opacified)

3.2. Nasal Cavity

A deviated septum, swollen or hypertrophic turbinates and/or the lining mucosa (frequently narrowing the surrounding meatal gaps), the anomaly known as concha bullosa, and missing walls typically as a result of sinus surgery are common characteristics that dentists detect in the nasal cavity.

3.3. Airway

In CBCT volumes, enlarged tonsils and/or adenoid tissues are usually observed. More frequently, tonsilloliths can appear as single, numerous, unilateral, and/or bilateral calcifications. In the tonsillar crypts, tonsilloliths are clumps of mucus, bacteria, and occasionally fungi that frequently produce odour. When examining a patient's airway, dentists and dental specialists who treat patients for obstructive sleep apnoea (OSA) or sleep disordered breathing usually measure the breadth, area, and volume of sections of the oral pharynx and pharynx (Fig.3).

3.4. Cervical Spine

The cervical spine's facet joints and vertebral bodies frequently experience osteoarthritis-related alterations. In CBCT data sets, loose bodies, subluxation between two joints, growth of osteophytes and subchondral cysts, and loss of joint space are frequently observed. The calcification of either the anterior paraspinal or posterior paraspinal ligaments is another alteration that can be noticed in greater FOV volumes connected to the vertebral bodies. If there are radiolucencies, they might be metastases from some of the more prevalent cancers, such as prostate, lung, cervical, and breast cancers. These radiolucencies are not consistent with the formation of subchondral cysts. Any alteration that stands out to a clinician as unusual must be reported, and in most circumstances the clinician should refer the patient back to their primary care physician and/or an orthopaedic specialist, internist, or rheumatologist.

3.5. Temporomandibular Joints

With CBCT, it is simple and accurate to image the TMJ complex, at least the condyles and associated bony structures, in both 2-D gray-scale imaging and 3-D colour reconstruction. It is best to visualise subchondral sclerosis, subchondral cyst formation, loose bodies, and changes in joint space, which are similar to the changes found in the vertebral bodies. In contrast to the cervical spine, the TMJ complex occasionally exhibits synovial chondromatosis (Fig. 4).

3.6. Dental Findings

Most oral maxillofacial radiologists limit their description of the changes in the section on bone levels, missing teeth, lesions of endodontic origin (new or residual), impactions, and malocclusion in the report because a dentist or dental specialist has already examined and charted a patient and taken a thorough dental and medical history. The majority of radiologists will additionally note any odontogenic cysts or tumours, suspected systemic conditions such osteomyelitis or systemic diseases, fractures, or symmetry in this area. The major goal of an oral and maxillofacial radiologist is frequently to find hidden pathology that the referring dentist is unaware of since it is not the main focus of the cone beam examination. However, if dentists or other non-radiologist dental experts choose to evaluate their own volumes, they are subject to the same standard of care as an oral maxillofacial radiologist and must identify and report any odd diseases that could be present in that volume. This is a big duty, and some dentists might need further education for it. Concerns about impacted teeth's relationships to nearby structures like the inferior alveolar nerve canal and sinus floors, unerupted maxillary canines' relationships to the root apices of maxillary incisors, and, in the case of dental implants, the location of the inferior alveolar nerve canal and the ridge's bone configurations, are just a few examples of requests that may be made.[15]

3.6a. Coronal status

It is important to look for radiographic evidence of access cavity preparation attempts. Additionally, beam hardening artefact from nearby teeth may also negatively affect interpretation; in these cases, a disclaimer such as "crown assessment is not feasible owing to beam hardening artefact" should be added to the radiography report. Because of its low resolution and the beam hardening caused by nearby teeth and restorations, CBCT should not be utilised as the primary approach for diagnosing caries [16].

3.6b. Root (canal) status

Anomalies of development (such as invaginations or evaginations, and, if possible, type/size); the number of roots, their curvature, and the arrangement of the canals. root filling quantity and quality. The apical level, quality, and existence of any unfilled canals should all be noted. Be factual when describing the imaging rather than opining. For instance, "poor-quality MB2 root canal filling" is an opinion but "the MB2 canal root filling is short of the apex by 5mm with unfilled apical canal" is a fact. Even if corrected, significant iatrogenic tooth damage should be noticed, such as the existence of (near) perforations.[17]

3.6c. Periapical/ periradicular bone loss

The ultimate diagnosis may be influenced by the kind and location of periapical and/or periradicular bone loss; for instance, "J-shaped" PDL widening is frequently linked to a vertical root fracture.

3.6d. Root resorption

Any resorptive defects should be noted, along with their presence, location, type (external cervical, external inflammatory, external replacement, internal inflammatory, and metaplastic/replacement root resorption), size, communication to the PDL space, and root canal system and classification (if applicable).

3.6e. Relationship to relevant adjacent anatomy

Root proximity to nearby anatomical structures, such as the inferior dental canal, nasopalatine canal, mental foramen, or maxillary sinus floor, should be observed. It is important to take note of any accompanying pathological symptoms, such as thickening of the maxillary sinus membrane.

3.6f. A radiological description of any pathosis followed by diagnosis

In a radiography report, the location, size, form, relationships, radiodensity, contour, internal structure, expansion, and impacts on adjacent structures should all be mentioned.

4. Other

A clinician can recognise a number of conditions or observations that call for sending a patient back to their primary care physician or to a medical care provider/specialist by using the "Other" portion of the authors' structured report. Internal carotid artery calcifications in the cervical and/or parasellar segments, calcifications of additional arteries, such as vertebral, calcifications in the soft tissues of the face or other regions, such as sialoliths, miliary osteomas, and calcified lymph nodes, and calcifications of the thyroid gland's cartilaginous horns are all examples of these conditions. Many of these calcifications, such as those found in the choroid plexuses, thyroid cartilage, and superior horns, are physiological and appear as people age. However, it is crucial that all arterial calcifications be documented since they raise the risk of hypertension, stroke, dysglycemia, and/or renal problems. These calcifications are as common in North America as type 2 diabetes mellitus, and dental experts who study CBCT volumes frequently come across them. End-stage renal failure can occur in patients with long-term type 2 diabetes mellitus who have untreated or undiagnosed renal problems (ESRD) [17,18].

5. Report on the CBCT data

Scout views and the entire CBCT data set must be evaluated and reported on in a logical manner. It is advised to carefully assess the entire set of information in all three orthogonal planes (axial, sagittal and coronal). Choosing to focus solely on one area of interest is bad practise (e.g. the tooth that has a suspected endodontic problem).

Although incidental discoveries are frequently made, it is deemed careless and consequently inadmissible to miss an important incidental discovery.

a. Systematic assessment of each tooth
b. Which teeth are unerupted?

5a. Systematic assessment of each tooth

Prior to evaluation, each tooth should be "uprighted" to provide the clearest picture of the anatomy using the native CBCT or third-party software. A multi-rooted tooth should have each root uprighted and examined separately.

5b. Which teeth are unerupted?

It is important to take notice of the existence, direction, and influence on nearby teeth and other anatomical structures.

6. The purpose of reporting in a structured way

In order to accurately assess patients' health state, it is the obligation of health care practitioners to collect information from patients. Even while such information is often focused on a primary problem, it is possible to gather secondary information that may also have an impact on a patient's health. The use of CBCT for dental treatment planning presents a situation in which additional data in the acquired image volume that are outside the purview of the primary dental concern could identify systemic conditions that could potentially have a direct impact on a patient's general health and longevity. A main provider or a secondary radiological reader will review the image data and produce the final report depending on their understanding of medicolegal concerns regarding the report's quality, accuracy, and intended use. Structured reporting serves the dual purposes of making information accessible to software tools designed to enhance communication and of clearly communicating with co-workers.

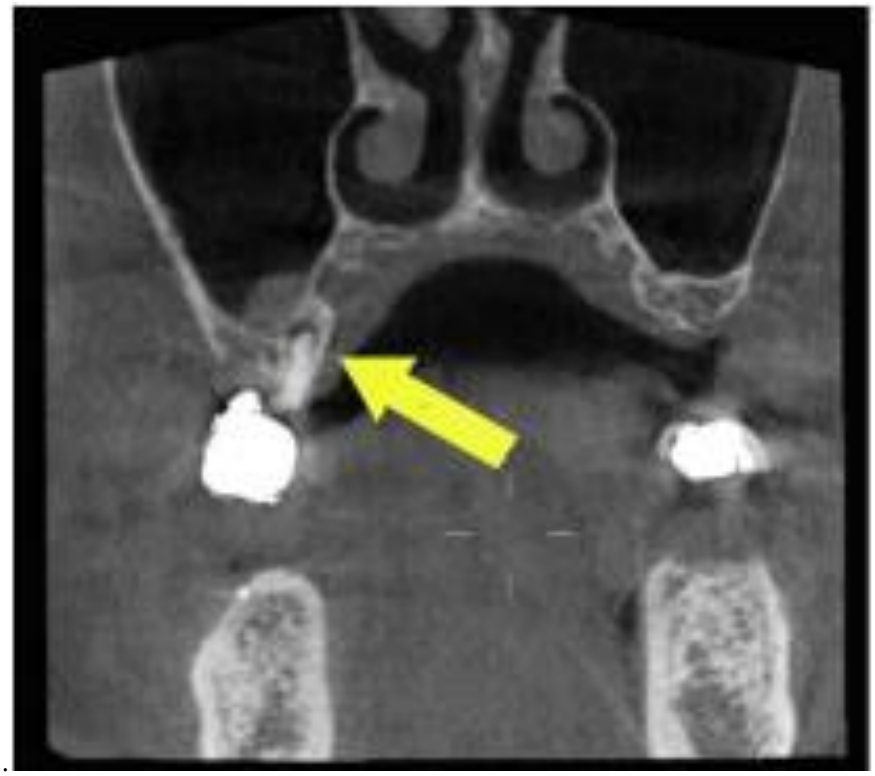

Figure 1. Radiopacity arising from the floor of the right maxillary sinus.

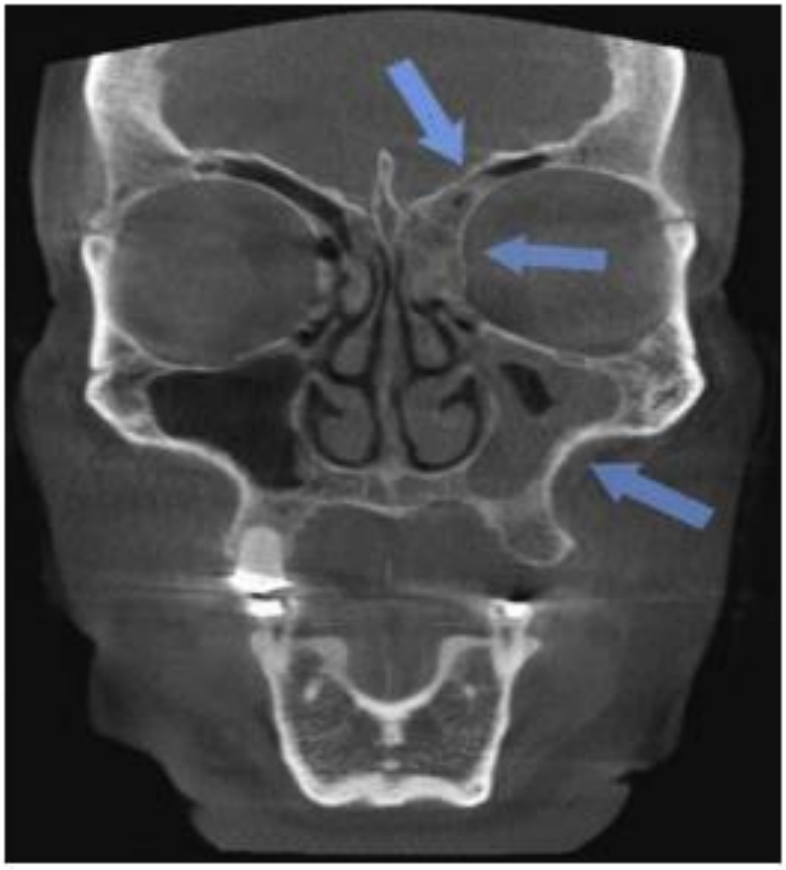

Figure 2. Inflammatory change in maxillary sinus, ethmoid air cell complex, and frontal sinus and ear region, called the lateral recess.

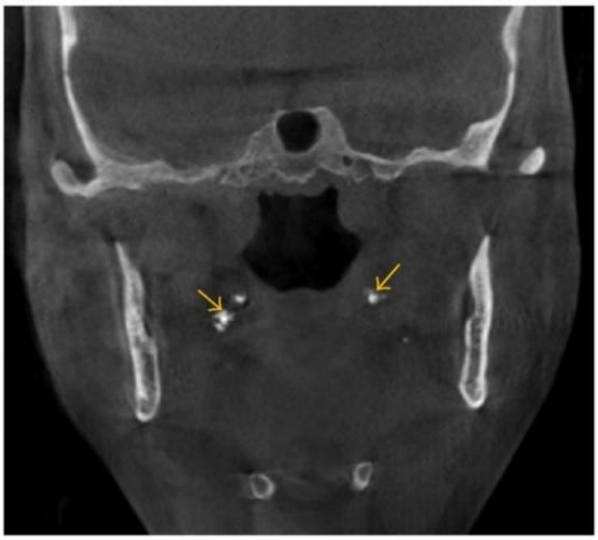

Figure 3. Bilateral Tonsoliths seen in coronal section showen by yellow arrows.

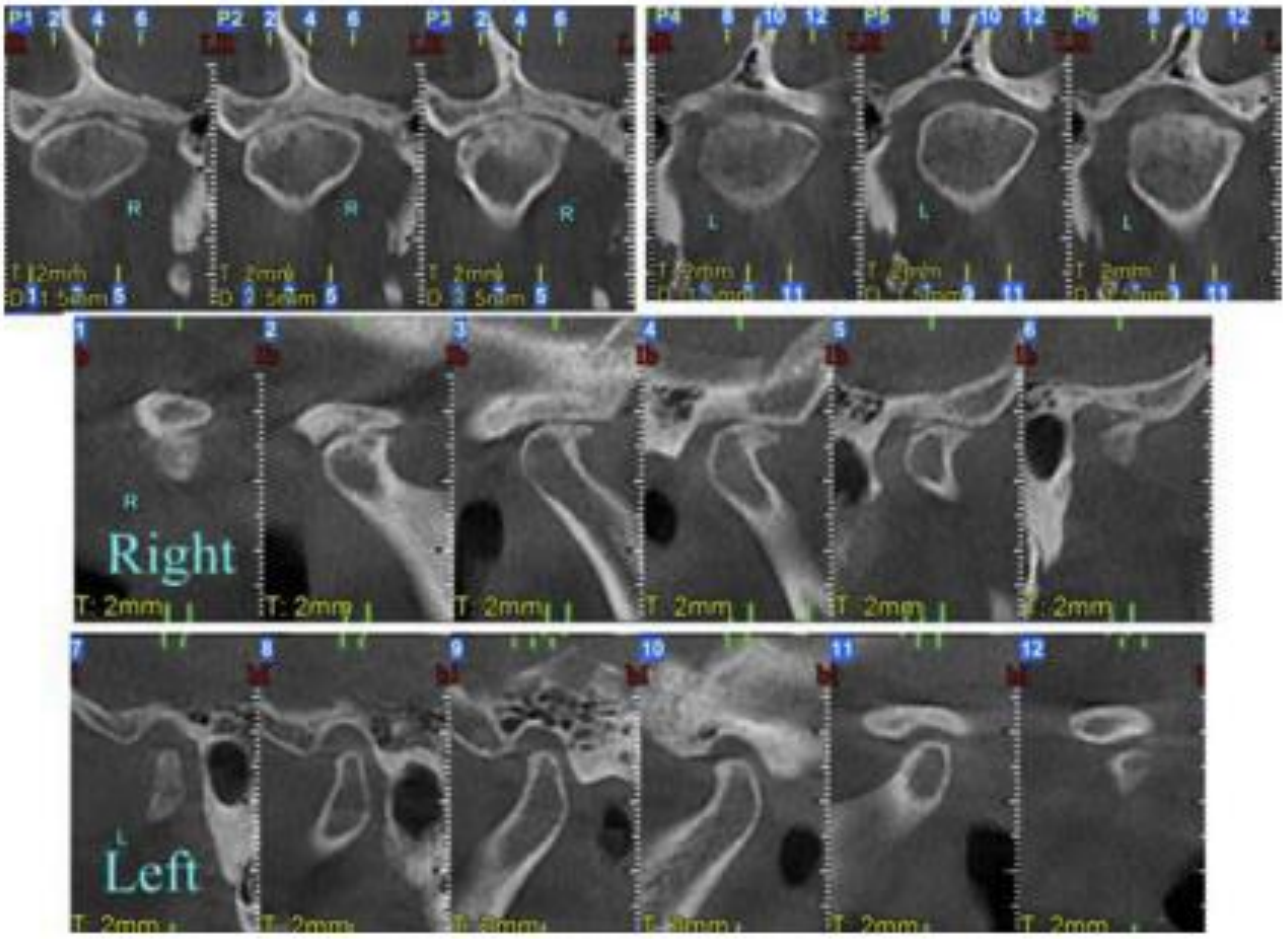

Figure 4. TMJ comparative joint series of serial coronal & condylar heads

Table 1. Stages of imaging chain [4,5]

Refer	To enable justification, provide the pertinent clinical information (provisional diagnosis and treatment plan), as well as your medical and dental history.
Justify	Compare the benefits and risks of the scan.
Protocol	Choose the proper exposure, area to image, and field of view settings.
Take the scan	Choose the appropriate patient, position them, conduct the scan, and then "post-process"
Report	Provide one structured, actionable report

Table 2. Radiographic Report [17,18]

Referrer:	Dr Name, Job title, Address for correspondence
Patient details:	Patient Name, Date of birth, Additional identifier (e.g., address)
Date of Study	
Need for Evaluation:	eg-Pathologic
Clinical details:	Signs and symptoms, Relevant medical history, Relevant dental history, Relevant previous imaging, Justification for scan, Specific questions to be answered (if any).
Radiography log:	kV, mA, Exposure time, Scan protocol, Operator, Grade, Comments
Report Introduction	
Paranasal Sinus **Nasal cavity** **Airway** **Cervical structures** **TMJ** **Dental findings**	
Dental findings	**Teeth Present :** Erupted/Unerupted **Coronal status** : Caries, External cervical resorption, Invagination (dens-indente) **Root (canal status) :** Number of root canals, Curvatures & configuration, Quality & extent of root filling/posts, Presence of fractured instruments, Presence of (near) perforation, invagination (dens-in-dente) **Root resorption**: Nature and location (internal [inflammatory/replacement)] or (external [cervical/ inflammatory/replacement)] Perforation of root (internal resorption) or root canal (external resorption) **Periapical/radicular radiolucency**: Radiological description including surrounding trabecular bone pattern
Relationship and effects on anatomical structures:	Movement/displacement or destruction of adjacent anatomy, proximity of vital structures (e.g., inferior alveolar bundle, maxillary sinus)
Peripheral findings:	Significant findings particularly if relevant to treatment or matters which need further management.
Conclusion:	Concise summary and answer to any questions asked
Sign off:	Name, Job title, Professional registration number.

7. Radiographic diagnosis

A measure of the reporter's confidence is preferred when making a radiographic diagnosis; for instance, "This is typical of" shows a high level of confidence in a single diagnosis; in contrast, "this may be A, B, or C" suggests that multiple diagnoses may be considered, and that perhaps additional investigations are needed. Usually, the differential diagnoses are listed from most likely to least likely in order of likelihood. In some circumstances, it might not be able to determine a lesion's exact diagnosis; nonetheless, it could be beneficial if the lesion or abnormality could be assigned to a "category," such as "The diagnosis is ambiguous, but this is probably a dental cyst." In order to determine if a precise diagnosis is achievable, one may also take into account the perspective of a second reporter. Options for treatment planning are often left up to the treating doctor, therefore they are not frequently mentioned in reports. This guideline obviously has an exception if the reporter feels that a significant issue has to be addressed, such as "the ragged radiolucency is suspected for cancer and immediate biopsy is suggested" [15]. It is a good idea to study the CBCT scan in all three planes once again to look for anything that wasn't the main focus of your investigation. Incidentalomas, like mucous retention cysts near the base of the maxillary antrum, are prevalent. Although these are unlikely to be clinically relevant to the dental issue at hand, it shows a careful method of assessing the scan's volume. The reporting of CBCT data sets could benefit in the future from artificial intelligence. The reporter's name, job title, registration number, and (electronic) signature are included at the end of the report for verification. It is also advisable to provide a contact mechanism, such as a secure email address, in case any more questions or clarifications arise. The patient can seek access to their clinical record, which includes radiological findings [16].

8. Conclusions

It is the duty of health care professionals to gather information from patients in order to assess their health state, evaluate whether treatment is necessary, and establish a foundation for their informed consent. The majority of the time, such information is focused on a primary issue, but there is a chance that secondary information may also be gathered that may have an impact on a patient's health. A main provider or a secondary radiological reader will review the image data and produce the final report depending on their understanding of medicolegal concerns regarding the report's quality, accuracy, and intended use. As with any radiography report, the goal of a CBCT report is to offer an accurate interpretation of the images evaluated. It should also, if applicable, provide a response to the clinical issue. When applicable, a radiographic report should be actionable and trigger the necessary care, which may include referral to a different speciality. If there is anything suspicious or out of the ordinary, the physician should seek the advice of a professional oral and maxillofacial radiologist or should feel outside their scope of practise. It is essential to complete sufficient postgraduate training in CBCT since this will provide doctors with the foundation they need to interpret and write acceptable and correct CBCT [16,17].

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