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Reporting rates and presence of dental pathology on CT brain examinations at a tertiary hospital in Johannesburg, South Africa

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ABSTRACT

Introduction

South Africa is burdened by a high prevalence of dental pathology. It is common to encounter this dental pathology on computed tomography (CT) brain scans.

Aims and objectives

To determine the presence of dental pathology on CT brain scans performed in a tertiary hospital and to assess whether radiologists reported on the encountered pathology. The study aimed to raise awareness among radiologists on reporting dental pathology and highlight the impact this has on oral and general health.

Design

A retrospective observational study.

Methods

Reports of CT brain scans performed between September 2019 and October 2019 were reviewed for dental findings. Two radiologists, Reader 1 and Reader 2, blinded to the reports' findings, reevaluated the corresponding CT images. Their findings were compared with the findings of the reports.

Results

None of the 160 reports reviewed had dental findings. Reader 1 and Reader 2, respectively, reported dental pathology in 92% and 79% of the CT scans. The most common dental findings were dental caries (79% and 53%), followed by missing teeth (66% and 53%), periodontal disease (59% and 38%), periapical disease (54% and 29%), odontogenic sinusitis (19% and 3%), restorations (11% and 9%) and dental injuries (4% and 4%).

Conclusions

Radiologists do not report on dental pathology encountered on CT brain scans. Recognition of dental findings may alter patient management and reduce related morbidity and mortality.

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Author's contribution

1. Dr Evidence Ndou-Van Zyl – was the principal investigator, conceptualised the project, drafted the research protocol, collected data and drafted the manuscript. Contribution- 50%
2. Dr Daniel Nicholas Prince- conceived the original idea, contributed to interpreting the results and supervised the research project. Contribution – 25%
3. Dr Suma Rajan- co-supervised the project and contributed to editing the research manuscript protocol and final manuscript. Contribution – 25%

INTRODUCTION

South Africa (SA) is a developing country with a high burden of oral health disease coupled with a severe shortage of healthcare professionals.[1] The SA healthcare system has two sectors: public and private.[2] Radiology services are primarily found in urban areas, with most radiologists in the private sector.[3] SA has 0.085 dentists per 1000 individuals.[4] In addition, only 10% of dentists are employed by the public sector, which treats 84% of the SA population.[2,5] The inequalities in oral healthcare access significantly burden the public sector to provide cost-effective, equitable, preventative and curative oral health services.[6]

Computed tomography (CT) of the brain scan is the most frequently performed CT in the world. Most CT brain (CTB) scans are performed to evaluate brain pathology, with far fewer scans dedicated to facial bones, orbits and sinuses.[7] The scan range of a CTB is from the top of the first cervical vertebrae lamina to the vertex.[8] However, teeth (entirely or partly) are usually inadvertently included in the field of view (FOV).

Regardless of the high burden of dental pathology, disease of the teeth and supporting anatomy frequently seen on CTB scans are often overlooked and underreported by radiologists. Reporting dental disease can alter patient treatment plans and help to avoid further complications.[7,9-10]

Dental caries (DC) is the most common dental pathology in SA.[1,11-12] Caries affect nearly 100% of adults between 35 and 44 years in most countries.[13] Untreated caries is the most common reason for patient consultations at oral healthcare

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centres in SA and indication for most dental extractions.[11,12] The development of DC is strongly associated with sugar consumption and a lack of oral healthcare services within communities.[1,6,14]

Periodontal disease (PD) is the most common cause of tooth loss among adults. There are two significant groups of PD: periodontitis and gingivitis.[9] Recent studies have reported on the systemic impact of PD and linked it to cardiovascular disease, stroke and hypertension in certain patient population groups.[7,15] A retrospective study performed in Cameroon between 2013 and 2015 found PD in 93.8% of patients with cardiovascular disease versus 70.5% of the general population.[15] In 2014, a case-control study in Senegal reported PD in 73.3% of stroke cases compared to 40.8% in controls.[16]

Periapical disease (PAD) is a spectrum of diseases resulting from an inflammatory reaction to bacteria within the root canal system. A common complication of untreated PAD is maxillary sinusitis. Other rare complications include deep neck infection, which may be life-threatening, orbital inflammation, intracranial complications from septic emboli and osteomyelitis.[17]

Radiologists, dental professionals and clinicians frequently miss odontogenic maxillary sinusitis (OMS).[18] It is estimated that PD and PAD cause 5%-38% of maxillary sinus disease. Failure to identify OMS on CT leads to incorrect treatment and disease recurrence even after completing antibiotics.[9]

SA has a high burden of injuries, with an injury-related mortality rate seven times the global rate.[19] Most emergency CTB scans in SA are trauma related.[20] Traumatic dental injuries comprise of crown and root fractures, luxations, intrusions or avulsions.[10,21] Maxillary incisors are the most commonly affected by dental trauma (DT).[21] About 85.4% of traumatic dental injuries in teeth are untreated.[22]

Dental implants and restorations have become popular due to their ability to restore nearly normal tooth function.[21] Most dental restorative material is more radiopaque than dentin and enamel, making it easier to see on imaging. However, dental restorations (DR) may also source severe streak artefacts that may obscure adjacent dental anatomy. When assessing restored teeth, one should look out for overhanging ledges, defective contact points, poor contours and secondary caries.[23] In addition, failed DR can migrate and cause damage to adjacent structures and inflammation of adjacent soft tissues.[21]

This study aimed to assess the presence of dental pathology on CTB scans within a selected SA population group and to determine whether radiologists reported the encountered dental pathology.

The study's primary objectives were to record dental pathology mentioned on original CTB reports, reevaluate CTB images for dental pathology, compare the findings from the original CTB reports to those from the revaluation and determine the presence of different dental diseases from the selected population group. The secondary objective was to recommend solutions for improving the reporting of dental findings.

MATERIALS AND METHODS

This retrospective cross-sectional study was conducted at a tertiary hospital in Johannesburg, SA, where all CT examination reports compiled by registrars were reviewed and approved by consultants. Registrars were defined as doctors undergoing training to become radiology specialists. Consultants were defined as qualified radiology specialists. All CTB scans with at least one set of visible teeth and approved radiology reports performed between 1 September 2019 and 31 October 2019 were compiled from the picture archiving and communication system (PACS). CT scans were obtained using a 128-slice Siemens, Phillips or Aquilion CT scanner following the CTB protocol. The exclusion criteria included CTB scans with incomplete sets of teeth, scans with severe streak artefacts from DR obscuring dental pathology, complete edentulism, scans initially reported by any of the authors or acknowledged persons and scans with incomplete reports. Incomplete radiology reports were defined as reports compiled by registrars and had not been approved by a consultant.

The principal researcher assessed the original radiology reports and recorded dental findings reported by registrars and consultants. Two consultants blinded to the findings of the original reports reevaluated the corresponding CT images for the presence of dental pathology. In this study, these two consultants, referred to as Reader 1 and Reader 2, are general radiologists with three years and one year of experience as qualified specialists, respectively. Their findings were categorised into DC, PAD, PD, OMS, DT, missing teeth and DR. Demographics in terms of sex and age of the participants were collected.

Ethical consideration

The Medical Human Research Ethics Committee of the University of the Witwatersrand granted ethics approval. The ethics approval number is M2111111. The study did not disclose the patients' personal details or identifying factors. All data retrieved from PACS and interpreted for this study was anonymised.

STATISTICAL ANALYSIS

The original radiology reports' dental findings were compared to those from Readers 1 and 2. The paired samples proportions test was used to compare the two groups, with the dependent variable being the detection of dental pathology by the radiologist who generated the original radiology reports or the Readers. Inter-rater agreement between Readers 1 and 2 was evaluated using Cohen's kappa statistics. Cohen's kappa statistic measures agreement between two assessors. It computes inter-reader reliability by calculating the percentage of items the readers agree on while accounting for the fact that they may have agreed on some items purely by chance.[24] Statistical significance was evaluated at $p<0.05$.

RESULTS

One hundred and sixty CTB scans met the inclusion criteria. Figure I illustrates the potential number of scans identified on PACS, the number and reasons for excluding scans based on the predetermined criteria.

The achieved sample size had a higher frequency of males than females, with 117 males (73.1%) and 43 females (26.9%). The participants' ages ranged from 18 to 81 years,

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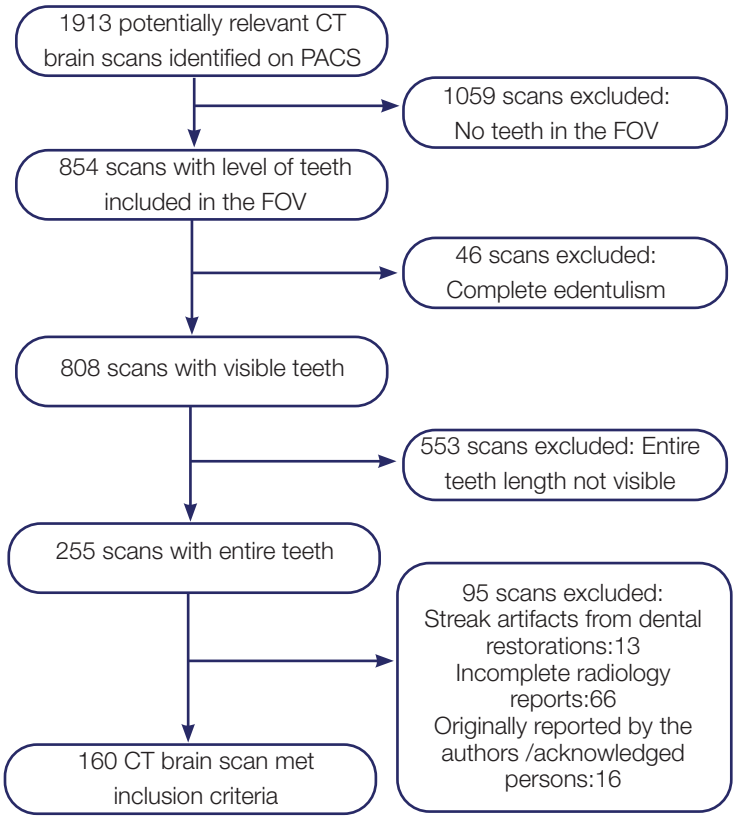


Figure I: Flow chart documenting the inclusion and exclusion criteria.

mean age of 39.6 years (standard deviation:14.5 years) and a median age of 37.5 years (interquartile range: 22.0 years).

The principal researcher reviewed the original radiology reports and found no dental findings reported by registrars and consultants who approved the reports. Two consultants, Reader 1 and Reader 2, who reinterpreted the CT images reported dental pathology in 92% and 79% of the scans

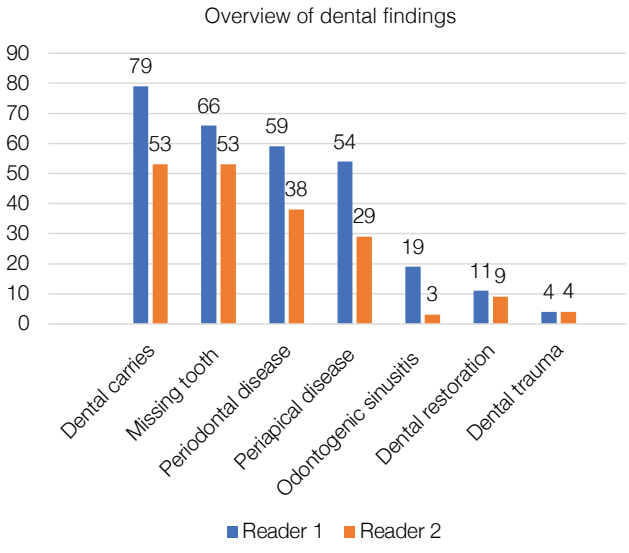


Figure II: Bar chart demonstrating an overview of dental findings by Reader 1 and Reader 2.

respectively and this was a statistically significant difference ($p<0.001$). The paired samples proportion test demonstrated a statistically significant difference between the findings of the original radiology reports a nd those of Readers 1 and 2, $p<0.001$ for both readers.

The most common dental findings by Reader 1 and 2 were DC, followed by missing teeth, PD, PAD, OMS, DR and DT (see Figure II below).

The inter-rater reliability was evaluated for the overall presence of dental disease. The number of cases in which both readers reported dental pathology was 125 (85%). Cohen's kappa coefficient was 0.45 (95% CI 0.25 - 0.61, $p<0.001$) and indicated a moderate agreement strength according to Altman guidelines.[25] The inter-rater reliability between Reader 1 and 2 for the spectrum of dental diseases was also calculated and indicated variable levels of agreements, see Table I below.

Pathology	Cohen's kappa	95%CI		P-value
		Lower	Upper	
Dental caries	0.38	0.26	0.51	<0.001
Periapical disease	0.39	0.26	0.51	<0.001
Periodontal disease	0.35	0.22	0.48	<0.001
Odontogenic maxillary sinusitis	0.06	-0.05	0.20	0.24
Dental trauma	0.60	0.18	0.89	<0.001
Missing tooth	0.67	0.56	0.78	<0.001
Dental restoration	0.58	0.33	0.79	<0.001
Overall dental pathology	0.45	0.25	0.61	<0.001

Table I: Inter-rater reliability for the spectrum of dental findings

DISCUSSION

Forty-two percent of reviewed CT scans had teeth either partially or entirely included in the FOV. However, to avoid the uncertainty of diagnosis, only CTB scans with the entire teeth length visible were considered for this study. Most dental findings can be reported even when the entire teeth are not included in the FOV. For example, a retrospective study by Bulbul et al. on detecting dental pathology on routine paranasal CT scans included any visible parts of maxillary teeth with mostly only roots of incisors seen. They reported a statistically significant prevalence of DC, developmental anomalies and PD within the selected population group.[26]

We would like to declare that although there is a significantly high number of CTB scans with teeth visible in the FOV, our institution adheres to the CTB protocol. There are various reasons beyond our study's scope which may result in teeth being accidentally included in the FOV.

This study identified complete nonreporting of dental pathology by radiology registrars and consultants. The original radiology reports did not mention dental pathology by the registrar and consultants. Overall, the study population had a high presence of clinically significant dental pathology. Readers 1 and 2 reported dental pathology in 92% and 79% of the reinterpreted CT scans, respectively.

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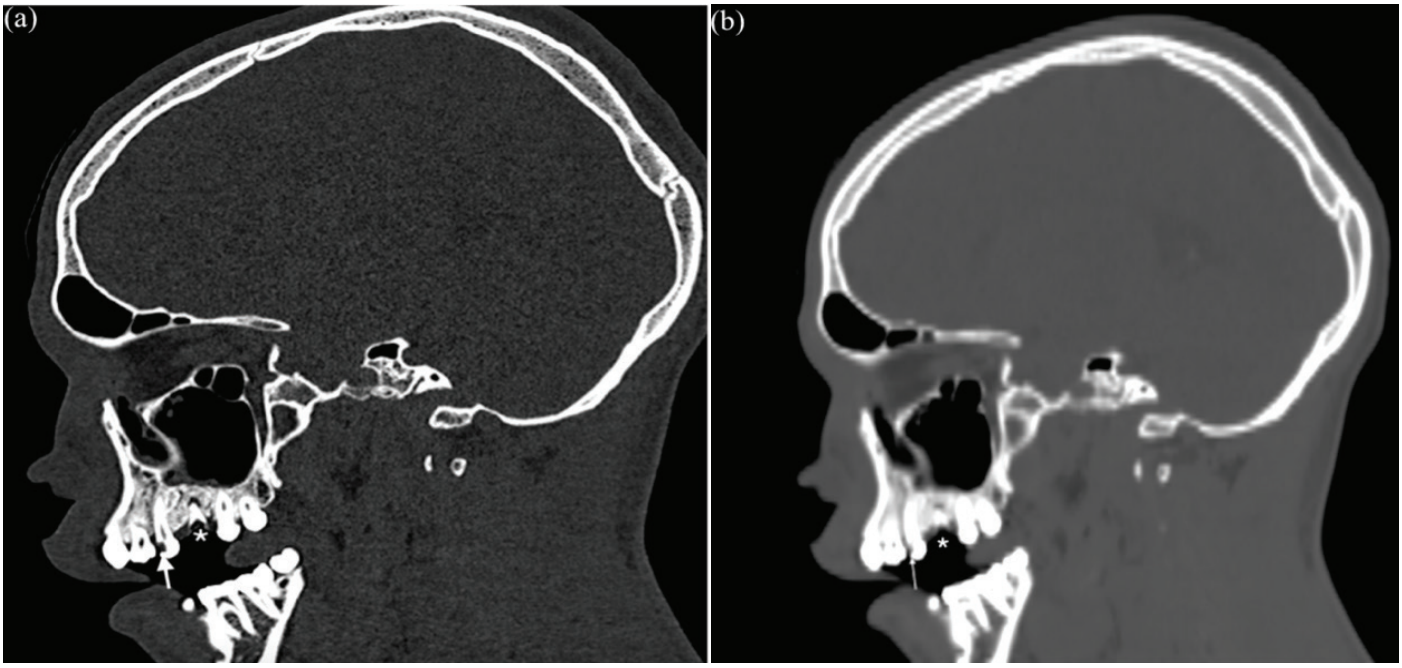


Figure IIIa: Sagittal CTB bone reconstruction image of a 22-year-old man scanned to exclude a traumatic brain injury illustrates occlusal dental caries of the left maxillary first molar (asterisk) and an approximal carious lesion of the second premolar (white arrow). Figure IIIb illustrates the same pathology on a soft tissue reconstruction bone window. Note how this reconstruction makes detecting dental pathology more difficult.

Our results conceded with those of a similar study done overseas by Hammond et al. in 2018. Their study reported underreporting of dental disease by radiologists on routine CTB scans, even after attempting to increase reporting rates by implementing a dental field in their CTB reporting template.[7]

DC was the most common dental pathology in our study population group, with Reader 1 and Reader 2 reporting a prevalence of 79% and 53%, respectively. In 2020 a cross-sectional analytic study on patients utilising dental public health services in KwaZulu-Natal districts by Mthethwa et al. also reported that carious disease was the most prevalent pathology in adults at 85% and the most common reason for patients' consultation for oral health services.[12] Another study in Cape Town in 2020 by Chikte et al. also reported DC as the most prevalent dental disease affecting 93.7% of the study population.[27] The presence of DC in our study was lower than that of Mthethwa et al. and Chikte et al. The significant difference between our study and these two studies was that they included oral examinations by dental experts. No comparable local study has yet been published on the prevalence of DC on CT.

In 2018 a similar study conducted overseas investigated the prevalence of DC in CTB scans performed in the emergency department and reporting practices by neuroradiologists in their department after noticing that the patients clinically presented with more caries than what was often reported by the radiologist. The findings of their study were similar to ours. They further discovered that the presence of untreated DC was higher in their study population than what has been documented in the general public statistics.[28]

On CT scan, DC will appear as a hypodense focal area of enamel and dentin loss on CT imaging, extending from the tooth's surface; see Figures IIIa and IIIb. Caries located on the chewing surface are called occlusal caries and are best visualised on sagittal and coronal planes. In contrast, approximal caries located in between teeth are easily identified in axial and coronal planes.[9,29] Early diagnosis of DC may lead to early intervention and restorative treatment, probably at a lesser cost. Our study's objective was merely to report on the presence or absence of dental carries; however, in daily practice describing the depth of the carious lesions may be crucial information to the referring clinical. This characterises the carious lesion on whether there is involvement of enamel, pulp or dentin and assists with prioritisation of patients on dental consultations.[28]

PD was the second most common dental disease found in our study. Previous studies have also identified PD as the most common dental disease after caries.[12] On CT scan, periodontitis is recognised by the expansion of the periodontal ligament space because of the destruction of the periodontal ligaments and inflammatory resorption of the lamina dura and cementum (Figure IV). In addition, furcation defects caused by bone loss at the anatomical site where roots divide on multirooted teeth are common.[9,30] CT scans are limited in diagnosing gingivitis, as it only affects the soft tissues and does not result in any measurable tissue or bone loss.[30]

A commonly encountered dental condition that was not recorded in our study is pericoronitis. Pericoronitis is inflammation of the soft tissues surrounding the crown of a partially erupted tooth and most commonly affects the mandibular third molar. The condition initially manifests as localised gingivitis and can spread to the local alveolar bone, even resulting in abscess formation in the deep neck spaces.[9,21] On imaging, pericoronitis typically appears as thickening and enhancement of peri-coronal tissues.[31]

In this study, PAD refers to odontogenic lesions that are evident on CT as lucencies around the apex of the teeth (see Figure V). These included periapical granulomas, abscesses and cysts. Radiologists should recognise acute PAD, manifesting as a periapical abscess from chronic PAD, for treatment prioritisation. A periapical abscess may result in acute osteomyelitis, which will appear as a permeative pattern of bone destruction.[9] This study reported statistically significant PAD present in up to 54% of the study population group. This is within the range of a 2021 systemic review and meta-analysis, which reported that 52% of the global population had PAD in at least one tooth, and the

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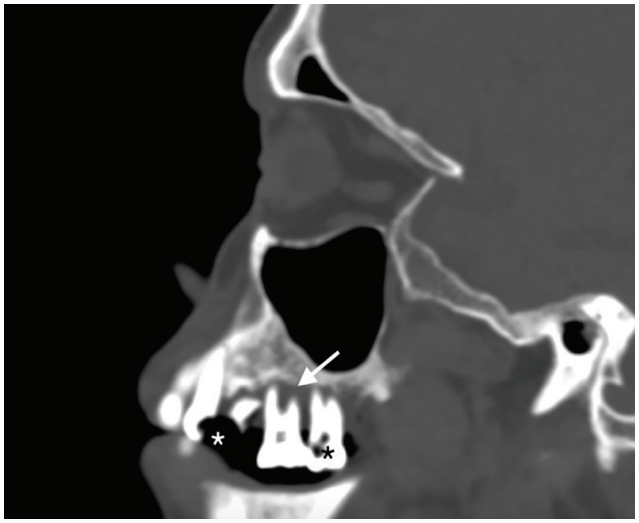


Figure IV: Sagittal CT image of a 67-year-old man demonstrating multiple dental caries (asterisk) and periodontal disease (white arrow), causing widening of the periodontal ligament space, bone loss and furcation defect uncovering the roots of the teeth.

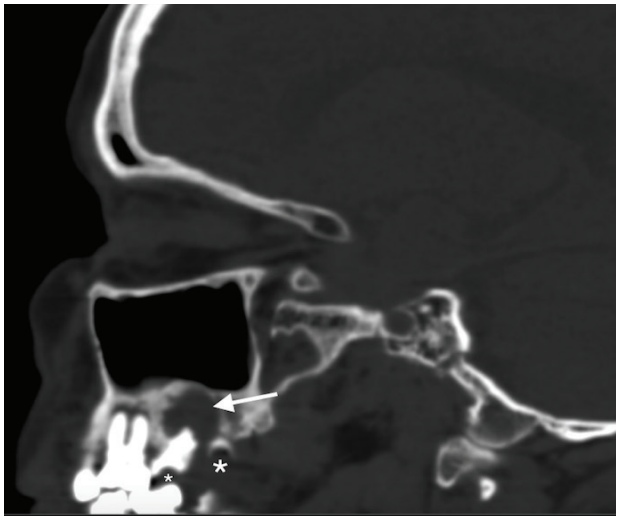


Figure V: Sagittal CT image of a 78-year-old woman illustrates right maxillary molar peri apical disease (white arrow) with severe thinning of the surrounding maxilla bone and dental caries (asterisk).

number was even higher in individuals from developing countries.[32]

Diseases of non-odontogenic origin may also cause lucencies around the tooth apex. Radiologists should be familiar with imaging findings of non benign lesions that present as periapical lucencies and differentiate them from PAD secondary to an infectious or inflammatory process.[17] No lesions with features suspicious of a non benign origin were reported in our study.

CT examination is essential in the diagnosis of odontogenic sinusitis. According to Bomeli et al., the presence of PD in adjacent teeth, periapical abscess, an oroantral fistula and a projecting premolar or molar tooth root is highly suggestive of odontogenic sinusitis.[33] The relationship between the maxillary sinus and teeth is best visualised on sagittal and coronal CT images.[9,34] While our study managed to identify clinically significant odontogenic sinusitis, Cohen's kappa value and Altman guidelines indicated disagreement between Reader 1 and Reader 2 on the frequency of odontogenic sinusitis.

Our opinion is that the absence of an identifiable dental source may make it difficult for radiologists to commit to diagnosing odontogenic sinusitis. Nevertheless, radiologists should always consider the possibility of OMS, especially in severe radiologic findings, unilateral maxillary sinusitis and interruption of the maxillary sinus floor, see Figures VIa and VIb.[33,35] A study on patients with confirmed OMS found that 36% of the participants had no apparent dental infection on CT.[18] When odontogenic sinusitis is diagnosed and both dental pathology and sinusitis are treated, complete resolution can occur in 90%-100% of cases.[35]

DT contributed a small percentage of our dental findings, with a moderate level of agreement between Reader 1 and Reader 2. Although traumatic dental injuries are prevalent, our study looked at the general population of patients and not solely trauma patients. A recent retrospective study

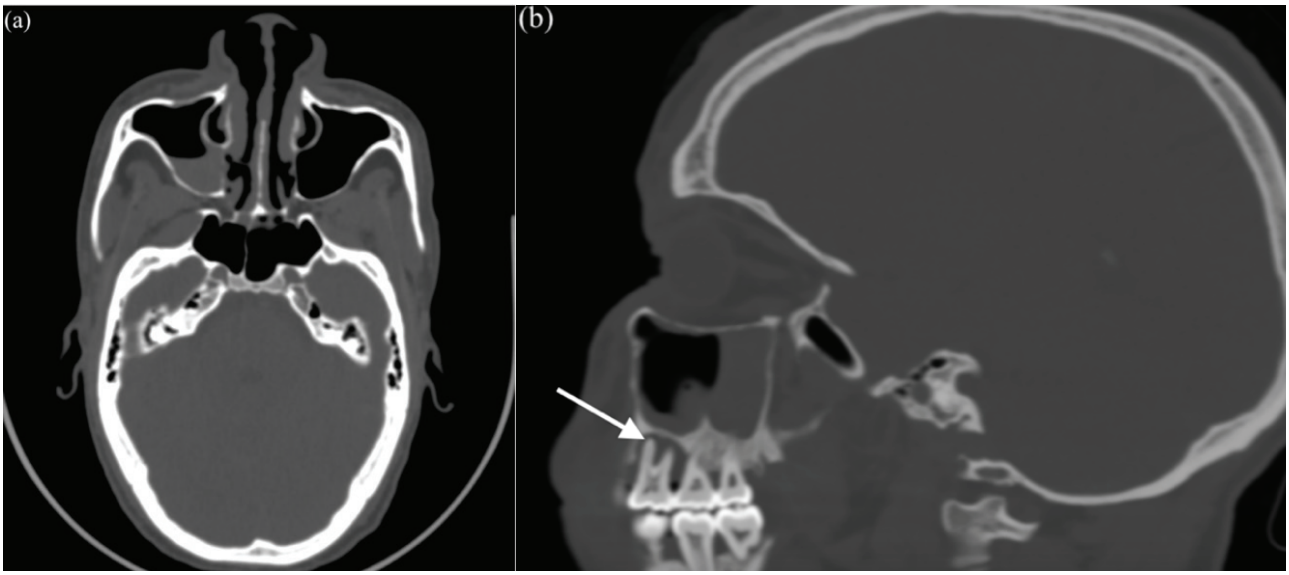


Figure VIa: Axial CT image of a 32-year-old man with odontogenic maxillary sinusitis illustrates unilateral opacification of the right maxillary sinus. Figure VIb is a sagittal image of the same patient illustrating apical periodontitis of the underlying right maxillary third molar (white arrow).

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by Meyer et al. on polytrauma patients who had whole-body CTs (ie, CT trauma series) identified dental injuries in 124 out of 994, with only 15 findings reported in the radiology reports. The correct diagnosis of DT in an acute setting is vital as injuries may complicate acute treatment like intubation, and aspirated tooth fragments may compromise the airways.[10] Therefore, timeous diagnosis and treatment of dental injuries can result in a more favourable outcome.

Delayed treatment for traumatic dental injuries may lead to devastating complications such as pulp necrosis, crown discolouration and root canal infection.[36] While injuries like tooth avulsions and luxation may be easily identifiable on CT, teeth fractures may be challenging to detect, especially if the fracture line is non-displaced.[9] Thus, cone beam CT has been proven to have higher diagnostic accuracy for dental injuries than multidetector helical CT.[37] Figure VII illustrates a study participant who had multiple dental injuries; although the mandibular fractures were reported, the dental injuries were not mentioned in the original report.

The presence of DR is an indicator of previously existing dental disease. Readers 1 and 2 identified restorations in 11% and 9% of the CT scans, respectively. Restorations with significant metallic components may cause substantial streak artefacts obscuring dental pathology in other teeth.[9] To avoid the potential underreporting of dental disease, all CT scans with streak artefacts from DR were excluded from this study. High levels of dental pathology with low levels of restorations evident on these scans could be related to a lack of access to dental care. Radiologists should know about the potential complications of DR which may lead to unfavourable outcomes if not addressed such as dislodgement, poor osseointegration and foreign body inflammatory reaction.[21] No complications of restorations were reported in this study.

Reporting missing teeth should be less challenging since the entire tooth does not have to be included in the scan FOV to identify this finding. In non-trauma-related cases, the absence of teeth should prompt radiologists to check for preexisting dental disease.[9] Both Readers reported a high presence of missing teeth among the study participants. The high prevalence of untreated DC and PD, both of which were reported in this study, is a major cause of tooth loss.[38] Many studies have associated tooth loss with a negative effect on the quality of life and functional capacity. In addition, the location and distribution of teeth loss affect the severity of impairment.[10,39] Interestingly, in 2021 Kimmie-Dhansay et al. conducted a study in Cape Town, where there is a high prevalence of tooth loss, and found that almost half of their 1615 study participants had no natural teeth. Their study concluded that loss of teeth did not impact the study subjects' oral health-related quality of life.[40]

There was a moderate level of agreement between Reader 1 and Reader 2 on the overall prevalence of dental pathology in reference to Altman guidelines. Agreement ranged from good to poor for the specific categories of dental findings. A good level of agreement was observed for missing teeth. The agreement was moderate regarding quantifying DR and DT. A fair agreement was observed for PD, PAD and DC. Lastly, there was disagreement on quantifying OMS.

The poor agreement on quantifying odontogenic maxillary sinusitis is most likely a result of the known difficulty in identifying OMS on multidetector CT. Fair agreement on the most prevalent dental diseases in the country and the world raises concerns as underdiagnosis and delayed treatment lead to serious



Figure VII: Sagittal image of a 22-year-old man who was assaulted illustrates an oblique fracture (white arrow) of the mandible involving the root of the mandibular third molar.

complications. In addition, most of the CT scans (67.5%) had no bone window reconstruction, which could have resulted in inferior resolution for identifying some of the dental pathologies. Figure IIIb demonstrates the difference in resolution when dental pathology is viewed from soft tissue reconstruction bone widow. Overall, the variance in interpretation between Readers 1 and 2 highlights unfamiliarity with dental pathology, a lack of experience in reporting dental findings by radiologists, and a need to raise the degree of certainty among radiologists. Educating radiologists on detecting dental pathology on CTB and implementing a dental field on the departmental CTB template may improve the reporting rates.

We recommend future studies to determine if the recommended solutions resulted in any changes in the radiologists' reporting rates of dental pathology.

LIMITATIONS

The study had a relatively small sample size. Further limitations include that this is a single-centre study, which means the findings on the radiologists' reporting rates are specific to this tertiary hospital and may not represent those of registrars and consultants from other academic institutions. In addition, due to the cross-sectional nature of the research, causal relationships may not be reliably determined.

CONCLUSION

Our study demonstrated a high prevalence of dental pathologies that were completely missed or ignored by the original interpreting registrars and consultant radiologists. This is highly concerning as underreporting dental pathologies can cause a delay in patient treatment and lead to significant morbidity. Therefore, training registrars and creating awareness among specialist radiologists regarding the imaging findings of dental disease should be prioritised.

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Conflicts of interest

There are no competing interests to declare.

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List of abbreviations

CT	–	Computed tomography
CTB	–	Computed tomography of the brain
DC	–	Dental caries
DR	–	Dental restorations
DT	–	Dental trauma
FOV	–	Field of view
OMS	–	Odontogenic maxillary sinusitis
PD	–	Periodontal disease
PAD	–	Periapical disease
PACS	–	Picture archiving and communication system
SA	–	South Africa

REFERENCES

1. Bhayat A, Chikte U. Human resources for oral health care in South Africa: A 2018 update. Int J Environ Res Public Health . 2019 May 14;16(10):1668. https://doi.org/10.3390/ijerph16101668
2. Ranchod S, Adams C, Burger R, et al. South Africa's hospital sector: old divisions and new developments. South Africa Health Review. 2017. https://journals.co.za/doi/pdf/10.10520/EJC-c80f3c5a8
3. National Department of Health (NDoH). 2030 human resources for health strategy: investing in the health workforce for universal health coverage. Pretoria: Government Printers, 2020
4. Strachan B, Zabow T, van der Spuy Z. More doctors and dentists are needed in South Africa. S Afr Med J. 2011 Jul 25;101(8):523-528. doi:10.7196/SAMJ.4894
5. Govender V, Chersich MF, Harris B, et al. Moving towards universal coverage in South Africa? Lessons from a voluntary government insurance scheme. Glob Health Action. 2013 Dec 24;6(1):19253. https://doi.org/10.3402/gha.v6i0.19253
6. Singh S. Dental caries rates in South Africa: implications for oral health planning. South African J Epidemiol Infect. 2011 Jan 15;26(4):259-261. https://doi.org/10.1080/10158782.2011.11441463
7. Hammoud K, Lanfranchi M, Adams D, Bedi HS, Mehan WA. Prevalence and reporting rates of incidental dental disease on head CT examinations. Acad Radiol. 2018 Oct 1;25(10):1318-1324. https://doi.org/10.1016/j.acra.2018.01.017
8. AAPM - American Association of Physicists in Medicine. Adult routine head CT protocols. Vol. 2, American Association of Physicist in Medicine. 2016. http://www.aapm.org
9. Scheinfeld MH, Shifteh K, Avery LL, Dym H, Dym RJ. Teeth: what radiologists should know. RadioGraphics. 2012 Nov;32(7):1927-1944. https://doi.org/10.1148/rg.327125717
10. Meyer HJ, Schramm D, Bach AG, Eckert A, Surov A. Dental trauma on whole body trauma CT – an underreported finding. Eur J Trauma Emerg Surg. 2022 Apr 15;48(2):1055-1060. https://doi.org/10.1007/s00068-021-01633-z
11. Thema LK, Singh S. Epidemiological profile of patients utilising public oral health services in Limpopo province, South Africa. African J Prim Heal Care Fam Med. 2017 Jul 12;9(1):1-5. https://doi.org/10.4102/phcfm.v9i1.1206
12. Mthethwa JM, Mahomed OH, Yengopal V. Epidemiological profile of patients utilising dental public health services in the eThekwini and uMgungundlovu districts of KwaZulu-Natal province, South Africa. South African Dent J. 2020 Nov 1;75(10):541-547. http://dx.doi.org/10.17159/2519-0105/2020/v75no10a2
13. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. Bull World Health Organ. 2005 Sep;83(9):661-669
14. Abid A, Maatouk F, Berrezouga L, et al. Prevalence and severity of oral diseases in the Africa and Middle East Region. Adv Dent Res. 2015 Jul 22;27(1):10-17 https://doi.org/10.1177/0022034515582062
15. Eno Belinga LE, Bell Ngan W, Lemougoum D, et al. Association between periodontal diseases and cardiovascular diseases in Cameroon. J Public Health Africa. 2018 Jul 6;9:1-4. https://doi.org/10.4081/jphia.2018.761
16. Diouf M, Basse A, Ndiaye M, Cisse D, Lo CM, Faye D. Stroke and periodontal disease in Senegal: case–control study. Public Health. 2015 Dec;129(12):1669-1673. https://doi.org/10.1016/j.puhe.2015.02.033
17. Chapman MN, Nadgir RN, Akman AS, et al. Periapical lucency around the tooth: radiologic evaluation and differential diagnosis. RadioGraphics. 2013 Jan;33(1):E15-E32. https://doi.org/10.1148/rg.331125172
18. Pokorny A, Tataryn R. Clinical and radiologic findings in a case series of maxillary sinusitis of dental origin. Int Forum Allergy Rhinol. 2013 Dec;3(12):973-979. https://doi.org/10.1002/alr.21212
19. Norman R, Matzopoulos R, Groenewald P, Bradshawa D. The high burden of injuries in South Africa. Bull World Health Organ. 2007 Jan;85(9):695-702. https://doi.org/10.2471/BLT.06.037184
20. Goldstein LN, Dawadi S, Viljoen IM. CT utilisation in a level one trauma center in South Africa. Cureus. 2022 Sep 11;14(9):4-11. doi:10.7759/cureus.29041
21. Loureiro RM, Naves EA, Zanello RF, Sumi D V, Gomes RLE, Daniel MM. Dental emergencies: a practical guide. RadioGraphics. 2019 Oct;39(6):1782-1795. https://doi.org/10.1148/rg.2019190019
22. Naidoo S, Sheiham A, Tsakos G. Traumatic dental injuries of permanent incisors in 11- to 13-year-old South African schoolchildren. Dent Traumatol. 2009 Apr;25(2):224-228.http://doi.wiley.com/10.1111/j.1600-9657.2008.00749.x
23. Whaites E, Hons BDS, Edin F, Eng F. Essentials of dental radiography and radiology Sixth Edition. London,UK: Elsevier Limited; 2020. 599-600
24. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. Biometrics. 1977:33(1):159-174. https://doi.org/2529310
25. Bland M. An introduction to medical statistics. Fourth Edition. New York: Oxford University Press; 2015. p. 319
26. Bulbul E, Yanik B, Demirpolat G. Detection of dental pathologies in routine paranasal CT scans: a retrospective study. J Clin of Diagn Res. 2017 Jul;11(7):TC17-TC20. https://www.doi.org/10.7860/JCDR/2017/27461/10287
27. Chikte U, Pontes CC, Karangwa I, et al. Dental caries in a South African adult population: findings from the Cape Town vascular and metabolic health study. Int Dent J. 2020 Jun;70(3):176-182. https://doi.org/10.1111/idj.12538
28. Brandfass JT, Ulano AC, Nickerson JP, Bazylewicz MP. Dental caries on CT in the ER population: prevalence and reporting practices. Emerg Radiol. 2019 Jan; 26(3):263-267. https://doi.org/10.1007/s10140-018-01663-y
29. Alves IDS, Vendramini DFV, Leite CDC, Gebrim EMMS, Passos UL. Dental findings on face and neck imaging. Radiol Bras. 2021 Apr;54(2):107-114. https://doi.org/10.1590/0100-3984.2019.0104
30. Assiri H, Dawasaz AA, Alahmari A, Asiri Z. Cone beam computed tomography (CBCT) in periodontal diseases: a systematic review based on the efficacy model. 2020 Jul;20(1):191. https://doi.org/10.1186/s12903-020-01106-6
31. Loureiro RM, Sumi DV, Tames HLVC, et.al. Cross-sectional imaging of third molar-related abnormalities. Am J Neuroradiol. 2020 Sept;41(11):1966-1974. https:// doi.org/10.3174/ajnr.A6747
32. Tibúrcio-Machado CS, Michelon C, Zanatta FB, Gomes MS, Marin JA, Bier CA. The global prevalence of apical periodontitis: a systematic review and meta-analysis. Int Endod J. 2021 May 22;54(5):712–735. https://doi.org/10.2214/AJR.12.9616
33. Bomeli SR, Branstetter BF, Ferguson BJ. Frequency of a dental source for acute maxillary sinusitis. Laryngoscope. 2009 Mar;119(3):580-584. https://doi.org/10.1002/lary.20095
34. Abrahams JJ, Glassberg RM. Dental disease: a frequently unrecognised cause of maxillary sinus abnormalities? Am J Roentgenol. 1996 May;166(5):1219-1223. https://doi.org/10.2214/ajr.166.5.8615273
35. Craig JR. Odontogenic sinusitis: A state-of-the-art review. World J Otorhinolaryngol Head Neck Surg. 2022 Mar;8(1):8-15. https://doi.org/10.1002/wjo2.9
36. Chaudhary S, Singh H, Gharti A, Adhikari B. Evaluation of clinical and radiographic findings among patients with traumatic dental injuries seeking delayed treatment. Int J Dent. 2021 Aug 23;2021:1-8. https://doi.org/10.1155/2021/9549508
37. Li F, Li J, Zhang D, Wu F. Role of computed tomography scan in dental trauma: a cross-sectional study. Dose-Response. 2018 Jul 1;16(3). https://doi.org/10.1177/1559325818789837
38. Petersen PE, Ogawa H. The global burden of periodontal disease: towards integration with chronic disease prevention and control. Periodontol 2000. 2012 Oct;60(1):15-39. https://doi.org/10.1111/j.1600-0757.2011.00425.x
39. Gerritsen AE, Allen PF, Witter DJ, Bronkhorst EM, Creugers NHJ. Tooth loss and oral health-related quality of life: a systematic review and meta-analysis. Health Qual Life Outcomes. 2010;8(1):126. https://doi.org/10.1186/1477-7525-8-126
40. Kimmie-Dhansay F, Pontes CC, Chikte UME, et al. Impacts of tooth loss on OHRQoL in an adult population in Cape Town, South Africa. Int J Environ Res Public Health. 2021 May 8;18(9):4989. https://doi.org/10.3390/ijerph18094989