RESEARCH

A comparative study of the diagnostic capabilities of 2D plain radiograph and 3D cone beam CT sialography

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Objective: The aim of this study was to compare the diagnostic capabilities of two-dimensional sialography with a novel three-dimensional technique using cone beam CT (CBCT).

Methods: 47 subjects underwent parotid or submandibular gland sialography over a 2 year period using both plain imaging and CBCT. Both image sets were anonymized and independently reviewed by three certified oral and maxillofacial radiologists blinded to the clinical data. McNemar's χ^2 test was used to determine differences between the two modalities for feature visualization and interpretation.

Results: CBCT outperformed plain imaging with respect to visualization of the gland parenchyma ($p < 0.001$) and identification of sialoliths ($p = 0.02$). Plain imaging outperformed CBCT for the identification of strictures ($p = 0.04$); however, the negative per cent agreement ("specificity") between the two imaging modalities was 100%. Although both imaging modalities performed equally in identifying normal and abnormal sialographic examinations, CBCT demonstrated a high negative per cent agreement for normal glands and a high positive per cent agreement ("sensitivity") for abnormal glands with inflammatory changes.

Conclusion: CBCT sialography allowed better visualization of gland parenchyma and identification of sialoliths. The high negative per cent agreement for strictures suggests that, if strictures are identified on CBCT images, then obstruction can be ruled in. Relative to plain images, the high negative per cent agreement for normal glands suggests that, if an abnormal finding is detected on CBCT images, then disease can be ruled in, and the high positive per cent agreement for glands with inflammatory changes suggests that inflammation can be ruled out if these changes are not seen on CBCT images.

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Introduction

Obstructive conditions of the major salivary glands are the most common abnormalities affecting nearly 1% of the population. From an imaging standpoint, the major salivary glands can be imaged using one of four

techniques: ultrasound (US), CT, MRI and sialography.¹ Ultrasound offers many advantages because it is inexpensive, widely available and safe.² However, US does not demonstrate all calculi accurately, or ductal damage caused by obstruction and inflammation.² CT has a greater sensitivity for sialoliths, but it cannot demonstrate small sialoliths. Moreover, it cannot demonstrate ductal damage.² MRI, unlike US and CT, can demonstrate changes in the ductal structures, but calcified sialoliths may be overlooked because of the signal void associated with calcified structures.²

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Sialography is a functional examination of the major salivary glands that involves the injection of a radio-opaque contrast agent into the ductal system of the gland prior to imaging. It is the only examination that demonstrates the fine, delicate anatomy of the ductal system, and most accurately visualizes sialoliths and strictures, two of the most common causes of obstruction.^{1,3} These capabilities make sialography the most suitable examination for investigation of obstructive conditions of the parotid and submandibular salivary glands. The capabilities of sialography are, however, restricted by the limitations of the imaging modalities to which it is coupled. Plain imaging has been used extensively with sialography; however the two-dimensional images that are generated may have limited diagnostic capability. Sialography has also been combined with medical CT, but the anisotropic voxel resolution may not demonstrate the fine anatomy of the gland ductal structures.⁴ Sialography has also been combined with fluoroscopy, but this modality delivers relatively significant doses of radiation to the patient.⁵

Recently, we and others have begun using cone beam CT (CBCT) as the imaging tool for sialography. CBCT overcomes many of the shortcomings of other imaging modalities and offers unique advantages such as isotropic voxel resolution. Previously, we have demonstrated our ability to achieve comparable effective radiation doses between plain imaging and CBCT sialography using the CB MercuRay system (Hitachi Medical Systems, Tokyo, Japan) by centring the gland of interest in a 6 inch field of view and using X-ray tube settings of 80 kVp and 10 mA.⁶ Specifically, a parotid CBCT examination using the above-mentioned settings resulted in an effective radiation dose of 60 μ Sv compared with 65 μ Sv for the plain image sialography series, for the submandibular gland, the effective radiation dose from CBCT was 148 μ Sv while from plain image sialography it was 156 μ Sv.⁶ Moreover, we were able to confirm adequate image quality when using these technical factors in a previous *in vitro* study using a sialography phantom.⁷

The purpose of this study is to compare the diagnostic capabilities of CBCT sialography with sialography using plain images. We hypothesize that CBCT sialography will have similar or greater diagnostic capabilities than sialography with plain imaging with regard to the visualization of normal gland structures such as the primary duct, the identification of abnormal findings such as sialoliths and, finally, image interpretation.

Materials and methods

47 subjects were recruited into this prospective clinical study over a 2 year time period from January 2009 to December 2010. Subject inclusion criteria were adults over 18 years of age with a suspected obstructive condition of a parotid or submandibular gland as

determined by history and clinical examination. Exclusion criteria included acute inflammation of the major salivary gland of interest, known or suspected allergy to iodinated contrast agents or an immediately anticipated thyroid function test. For each subject the following clinical data were collected prior to the sialography procedure: subject age, gender, medical history, chief complaint, subject self-assessment of pain presence and pain quality, swelling, abnormal taste, mouth dryness and provoking stimulus. In addition, extra- and intraoral examinations were performed to determine the presence of a swelling, and salivary quantity and quality (clear or cloudy). Ethical approval was obtained from the University of Toronto Research Ethics Board (Research Ethics Board protocol reference #23693).

Sialography was performed by a resident in oral and maxillofacial radiology closely supervised by a faculty member certified as a specialist in oral and maxillofacial radiology. The orifice of the primary duct of the salivary gland under examination was dilated with a series of metal probes, and this was followed by cannulation of the primary duct with a 24 G (Pajunk Medizintechnologie, Geisingen, Germany) or 30 G catheter (Cook, Bloomington, IN). Between 1 ml and 10 ml of Omnipaque® 180 mg I ml⁻¹ (Iohexil injection 39%, General Electric Healthcare Canada Inc., Mississauga, ON, Canada) were injected slowly into the duct of the gland until the subject reported maximum tolerance to a feeling of pressure in the gland. A lateral skull plain image was then made using the GE focus system (General Electric Corporation, Henry Schein Ash Arcona, Niagara-on-the-Lake, ON, Canada) and a photostimulable phosphor sensor (CR850, Carestream, Rochester, NY) to confirm optimal fill of the ductal structures of the gland prior to CBCT image acquisition. If contrast fill was deemed inadequate, additional contrast was injected and another lateral skull plain image was made.

CBCT imaging was performed with the CB MercuRay CBCT unit (Hitachi Medical Systems) using a 6 inch field of view, 80 kVp and 10 mA with the occlusal plane of the dentition parallel to the floor, and the imaging volume centred on the gland of interest. 5 min following catheter removal, a second lateral skull plain image was made to evaluate contrast clearance from the gland. The two lateral skull plain images represented the two-dimensional part of the study, and these were used for comparison with the CBCT images. This protocol allowed us to acquire and then compare the images of the same gland in the same subject using both modalities.

Three certified specialists in oral and maxillofacial radiology reviewed the images after undergoing a calibration exercise prior to image analysis. The calibration exercise included a review of 12 archived cases of sialography performed with plain images, with the aim of standardizing structural appearances of the gland and the definitions of descriptive terms. Prior to review by

the oral and maxillofacial radiologists, all images were anonymized. The three observers reviewed the plain and CBCT sialographic images for each subject separately with a wash-out period of at least 1 week. As all the images were digitally acquired, they were viewed using the CBWorks 2.0 software (CyberMed, Seoul, Republic of Korea) on a 19 inch Dell® Ultrasharp 1907 flat panel LCD screen (Dell Inc., Round Rock, TX) with a maximum resolution of 1280 × 1024 pixels in a dimly lit room. The observers were permitted to enhance the images by manipulating the brightness and contrast as they chose. In addition, they were permitted to review the three-dimensional renderings of each CBCT image dataset in their entirety. The reviewing oral and maxillofacial radiologists were blinded to the clinical data and were asked to make observations with respect to the features listed in Table 1. Agreement between two of the three oral and maxillofacial radiologists was used to determine the presence or absence of an imaging finding. No attempt was made to reconcile disagreements. In addition, one of the oral and maxillofacial radiologists reviewed 20 randomly selected cases (including both plain and CBCT images) twice to determine intraobserver reliability.

Statistical analysis was performed using the SAS software Version 9.1 (SAS Institute Inc., Cary, NC). Descriptive statistics were performed for the clinical data and for the radiographic features listed in Table 1, and McNemar's χ^2 test was used to determine differences between the two imaging modalities with regard to the same outcomes. Because there is no gold

standard (*i.e.* histopathological confirmation) for this work, unbiased estimates of “accuracy”, “sensitivity” and “specificity” cannot be calculated and therefore the terms should not be used.⁸ Instead, the same numerical calculations were made, but the estimates are called “overall per cent agreement” instead of “accuracy”, “positive per cent agreement” instead of “sensitivity” and “negative per cent agreement” instead of “specificity”.⁸ This modification reflects that the estimates are not of accuracy but of agreement of the new test (CBCT) with the non-reference standard (plain radiographs).⁸

- “Overall per cent agreement” = the number of cases agreed upon by both imaging modalities/the total number of cases.
- “Positive per cent agreement” = the number of cases that both imaging modalities agreed upon as demonstrating the radiographic feature or findings/the total number of cases that demonstrated the radiographic feature or finding on plain images.
- “Negative per cent agreement” = the number of cases that both imaging modalities agreed upon as not demonstrating the radiographic feature or finding/the total number of cases that did not demonstrate the radiographic feature or finding on plain images.

Comparison was performed between the two imaging modalities for visualization of normal structures, identification of abnormal findings and interpretation. Cohen's kappa was used to calculate inter- and intraobserver agreement, and the Landis and Koch guidelines were used to interpret them. The null hypothesis was rejected when the α (p)-value was less than 0.05.

Results

The 47 subjects ranged in age from 21 years to 87 years with a mean of 48 years. Gender distribution was approximately equal with 27 females (57.4%) and 20 males (42.6%). The majority of subjects (29 cases, 61.7%) were healthy with non-contributory medical histories. 16 subjects (34.0%) reported a non-contributory health ailment. Two subjects had received previous radioactive iodine treatment.

In total, 32 parotid glands and 15 submandibular glands were examined. Referral to our clinic for sialography was primarily from oral and maxillofacial surgeons (25 cases, 53.2%), followed by oral and maxillofacial pathologists (14 cases, 29.8%), general dentists (6 cases, 12.8%) and otolaryngologists (2 cases, 4.3%). All subjects were symptomatic, and intermittent swelling was the most common chief complaint of 32 subjects (68.1%). 3 subjects (6.4%) experienced only a single episode of swelling. Most subjects (26, 55.3%) reported pain. 14 subjects (29.8%) reported dull pain

Table 1 List of the radiographic features and findings that were reviewed

<i>Radiographic feature</i>	<i>Radiographic finding</i>
<i>Normal structures</i>	
Primary duct	Visualization Presence of abnormalities
Secondary ducts	Visualization Presence of abnormalities
Parenchyma	Visualization Presence of abnormalities
<i>Abnormal features</i>	
Sialoliths	Number Size Location
Strictures	Number Size Location
Ductal dilatation	Severity Location
Acinar pooling	Number Distribution Size
Mass	Location Borders Internal structure Effect on surrounding structures
Interpretation	Normal Inflammatory (sialadenitis/ sialodochitis) Autoimmune Other

and 8 subjects (17.0%) reported sharp pain. 4 other subjects (8.5%) reported “discomfort” and 21 subjects (44.7%) reported no pain. The majority of subjects denied any abnormal taste in the mouth or dryness, only 29.8% and 21.3% reported these symptoms, respectively. 20 subjects (42.6%) could relate their symptoms of swelling and/or pain to meal time, while 3 subjects (6.4%) noticed their symptoms to be worse in the morning. One subject claimed tongue movement was the provoking stimulus. At the time of the examination, saliva could be easily expressed from the gland of interest in the majority of subjects (31 cases, 66.0%). For 13 subjects (27.7%) saliva was difficult to expel, and for 3 subjects (6.4%) we were unable to expel any saliva from the gland of interest. In the majority of subjects (46 cases, 97.9%), saliva was clear. Cloudy saliva was found in only 1 case (2.1%). None of the subjects in this study suffered any adverse reactions to the contrast agent or a complication following the procedure.

The two imaging modalities agreed on the interpretation of 39 out of 47 subjects. Of these, 4 subject image sets (8.5%) were interpreted as being within the range of normal and 35 (74.5%) were interpreted as abnormal. The majority of the abnormal image sets (29 cases) were interpreted as being consistent with changes secondary to inflammation (sialodochitis and sialadenitis). Two image sets were interpreted as an autoimmune condition (Sjögren syndrome) and two others as tumours. One image set was interpreted as gland fibrosis and another as sialadenosis. These findings are listed in Table 2.

The abnormal findings listed in Table 1 were identified by the observers more frequently on CBCT images than on plain images and are summarised in Table 2. The only exception to this was strictures which were identified more frequently on the plain images. The most common location for sialoliths and strictures was the primary duct. Solitary sialoliths were identified more often than multiple sialoliths, and these ranged in

Table 2 Radiological interpretation and identification of features as determined by the reviewers

Primary outcome (interpretation)	Cone beam CT (%)		Plain film (%)		Both modalities (%)	
Normal	06/47	(12.8)	10/47	(21.3)	04/47	(08.5)
Abnormal	41/47	(87.2)	37/47	(78.7)	35/47	(74.5)
Inflammation (sialadenitis, sialodochitis) ^a	33	(80.5)	30	(81.1)	29	(82.9)
Autoimmune (Sjögren syndrome)	2	(04.9)	2	(05.4)	02	(05.7)
Gland fibrosis	2	(04.9)	1	(02.7)	01	(02.9)
Sialadenosis	1	(02.4)	2	(05.4)	01	(02.9)
Tumour	3	(07.3)	2	(05.4)	02	(05.7)
Secondary outcomes						
Visualization of primary duct	46/47	(97.9)	46/47	(97.9)	45/47	(95.7)
Visualization of secondary ducts	43/47	(91.5)	42/47	(89.4)	39/47	(83.0)
Visualization of parenchyma	39/47	(83.0)	21/47	(44.7)	19/47	(40.4)
Presence of sialoliths	22/47	(46.8)	15/47	(31.9)	15/47	(31.9)
Number						
Single	15	(68.2)	10	(66.7)		
Multiple	7	(31.8)	5	(33.3)		
Location						
Primary duct	15	(68.2)	10	(66.7)		
Secondary ducts	5	(22.7)	5	(33.3)		
Primary and secondary ducts	2	(09.1)	0	(00.0)		
Presence of strictures	19/47	(40.4)	25/47	(53.2)	19/47	(40.4)
Number						
Single	11	(57.9)	6	(24.0)		
Multiple	8	(42.1)	19	(76.0)		
Location						
Primary duct	9	(47.4)	12	(48.0)		
Secondary ducts	3	(15.8)	5	(20.0)		
Primary and secondary ducts	7	(36.8)	8	(32.0)		
Presence of ductal dilatation	33/47	(70.2)	27/47	(57.4)	25/47	(53.2)
Severity						
Mild	7	(21.2)	7	(26.0)		
Moderate	4	(12.1)	9	(33.3)		
Severe	22	(66.7)	11	(40.7)		
Location						
Primary	10	(30.3)	8	(29.6)		
Secondary	2	(06.0)	2	(07.4)		
Primary and secondary ducts	21	(63.7)	17	(63.0)		
Presence of acinar pooling	9/47	(19.1)	4/47	(08.5)	01/47	(02.1)
Size (mm)	0.1–6.5		0.2–5.0			
Distribution						
Homogeneous	2	(22.2)	1	(25.0)		
Heterogeneous	7	(77.8)	3	(75.0)		

^aWe are only interested in these two subcategories of inflammation.

size from 1.0 mm to 24.0 mm. Solitary strictures were identified more commonly on CBCT while multiple strictures were identified more frequently on plain imaging. Ductal dilatation was the most common abnormal finding identified on both plain images (57.4%) and CBCT images (70.2%). The primary and secondary ductal structures were more commonly involved and the severity of ductal dilatation was evaluated to be severe in most cases as assessed on both CBCT and plain imaging. In addition, the globular collections of contrast material seen in acinar pooling were most often described as non-uniform in distribution and size as they ranged from 0.1 mm to 6.5 mm on both CBCT and plain imaging.

The overall per cent agreement (“accuracy”) between the two imaging modalities for visualization of the primary duct was high (95.7%). As the gland structures became finer and more delicate (*i.e.* secondary ducts and parenchyma), the overall agreement between the two imaging modalities decreased to 85.1% and 53.2%, respectively. Differences for visualization of the parenchyma were statistically significant ($p < 0.001$) with more cases visualized on CBCT (39 cases, 83.0%) than plain images (21 cases, 44.7%). Interobserver agreement for both plain imaging and CBCT ranged from “moderate to very good” for visualization of the primary and secondary ducts, and ranged from “fair to moderate” for visualization of the parenchyma. Intraobserver agreement was “good” for visualization of the normal structures (plain image 0.71, CBCT 0.79). These findings are summarised in Table 3.

With regard to the identification of abnormal findings (Table 3), the positive per cent agreement (“sensitivity”) between the two imaging modalities was 100% for the identification of sialoliths and the negative

per cent agreement (“specificity”) was 100% for the identification of strictures. Both of these findings were statistically significantly different ($p < 0.05$) between the two imaging modalities. Interobserver agreement for all the abnormal findings listed in Table 1 ranged from “moderate to very good” for CBCT and “fair to very good” for plain images while intraobserver agreement was “good” for both imaging modalities (plain image 0.73, CBCT 0.75).

Overall per cent agreement between the two imaging modalities was similar (83.0%) for normal and abnormal glands. The positive per cent agreement was higher (96.7%) for changes secondary to inflammation whereas the negative per cent agreement was higher (94.6%) for normal salivary glands. Interobserver agreement for interpretation ranged from “fair to good” for plain imaging and “good to very good” for CBCT. Furthermore, intraobserver agreement was “good” (plain image 0.80 and CBCT 0.78). These findings are outlined in Table 3.

Discussion

Sialography was first performed in 1902,⁹ and is regarded as the gold standard for depicting the delicate ductal structures of the major salivary glands^{1,10,11} and identifying non-calcified sialoliths and ductal strictures.^{1,3} The purpose of this study was to determine whether sialography performed with CBCT is superior to sialography performed with plain imaging.

Interpretation was our primary outcome and we found the overall per cent agreement (“accuracy”) between the two imaging modalities to be the same for

Table 3 Primary and secondary outcomes, overall per cent agreement, and positive and negative per cent agreements for cone beam CT (CBCT) and plain imaging sialography

Outcomes	Overall % agreement	Positive % agreement	Negative % agreement	p-Value ^a	Cohen's kappa (interobserver)
Primary outcome					
Interpretation					CBCT: 0.73–0.90 plain film: 0.39–0.75
Normal	83.0	40.0	94.6	0.3	
Abnormal					
Inflammatory	89.4	96.7	76.5	0.4	
Secondary outcomes					
Visualization of primary duct	95.7	97.8	00.0	0.5	CBCT: 0.52–1.00 plain film: 0.56–0.97
Visualization of secondary ducts	85.1	92.9	20.0	1.0	CBCT: 0.61–0.83 plain film: 0.63–0.83
Visualization of parenchyma	53.2	90.5	23.1	< 0.001	CBCT: 0.22–0.58 plain film: 0.35–0.60
Presence of sialoliths	85.1	100.0	78.1	0.02	CBCT: 0.62–0.84 plain film: 0.75–0.88
Presence of strictures	87.2	76.0	100.0	0.04	CBCT: 0.82–0.91 plain film: 0.34–0.64
Presence of ductal dilatation	78.7	92.6	60.0	0.1	CBCT: 0.82–1.00 plain film: 0.77–0.91
Presence of acinar pooling	76.6	25.0	81.4	0.2	CBCT: 0.63–0.73 plain film: 0.44–0.65

^aMcNemar's χ^2 .

interpreting the examinations as normal or abnormal. We also noted that the positive per cent agreement (“sensitivity”) was higher for changes seen secondary to inflammation and the negative per cent agreement (“specificity”) was higher for normal salivary glands. The high positive per cent agreement (96.7%) for the identification of abnormal glands, particularly those demonstrating changes secondary to inflammation suggests that inflammation can be confidently ruled out if these changes are not seen on CBCT images. In contrast, the high negative per cent agreement (94.6%) for normal glands suggests that if an abnormal finding is detected on CBCT images, then disease can be confidently ruled in. Figure 1 is an example of a case that was interpreted by all three observers as normal on plain imaging but was interpreted as demonstrating changes secondary to sialodochitis when the CBCT images were reviewed.

Sialadenitis of the major salivary glands, especially the chronic type, is a relatively common condition with approximately two-thirds of cases reportedly being due to ductal obstruction.^{3,12–14} Ductal obstruction, in turn, may have as primary causes calculi, strictures and fibromucinous plugs, and as secondary causes mass lesions that may impinge on the ductal structures and cause them to occlude. In this study, sialoliths were the most common cause of obstruction identified on both CBCT (46.8%) and plain (31.9%) images. These findings are consistent with the work of Ngu *et al*,¹ who reported that the most common cause of ductal obstruction (73.2%) was salivary calculi, followed by strictures (22.6%) and mucous plugs (4.2%). Of note was our finding that more sialoliths were identified on CBCT images than on plain images. Dreiseidler *et al*¹⁵ suggested that two-dimensional plain

images have limited success in identifying sialoliths because of overlapping anatomical structures. Moreover, Som and Curtin³ estimate that approximately 20% of submandibular gland sialoliths and 40% of parotid gland sialoliths are missed on plain images due to low calcium content. Figure 2 is an example of one such sialolith that was missed on plain imaging because of overlapping structures but identified on CBCT.

Solitary sialoliths are more common than multiple sialoliths, and these are more commonly found in the primary ducts of glands.³ Our data are in agreement with these findings. The high (100%) positive per cent agreement between the CBCT and plain imaging datasets suggests that if no sialoliths are detected on CBCT images, then they can be confidently ruled out.

Strictures, like sialoliths, are most often single and more commonly found in the primary duct.¹ In the current study, the CBCT results support these findings. However, more strictures were identified on plain images and they were more often described as multiple on plain imaging. The high (100%) negative per cent agreement of these data suggest that if a stricture is identified on CBCT images, then an obstruction can be confidently ruled in.

Ductal obstruction, regardless of cause, results in the classic painful meal time swelling of the affected gland that is frequently described in the literature and was the most common complaint of subjects in this study.^{3,14,16} Upon imaging of the affected gland, sialectasia of the ductal structures is the most prominent feature as is demonstrated in the literature and was confirmed in this study.^{3,14}

CBCT sialography is a novel investigation, and there are few case reports in the literature. Drage and

Figure 1 This is a case of a 26-year-old female that came to our clinic complaining of a single episode of painful swelling in the area of the left submandibular salivary gland. Image (a) is the lateral skull plain film radiograph that was made following contrast administration. All three observers agreed on the interpretation of normal when this image was reviewed. The observers dismissed the area of dilatation in the proximal part of the primary duct (arrow) as a point of branching rather than abnormal. Images (b) and (c) are maximum intensity projection cone beam CT images in the sagittal and axial planes, respectively. These images demonstrate that the area of ductal dilatation is not due to branching and were thus interpreted by all three observers as changes secondary to sialodochitis

Figure 2 This is a case of a 52-year-old female that was referred to our clinic to investigate episodes of intermittent painful swellings in the area of the left parotid gland. Image (a) is the lateral skull plain film radiograph that was made following contrast administration and demonstrates severe sialectasia of the primary and secondary ductal structures but with no obvious cause. Images (b) and (c) are maximum intensity projection cone beam CT images of the same gland in the sagittal and the axial planes, respectively, identifying a cause for the sialectasia, a non-calcified sialolith immediately proximal to the duct orifice (arrow)

Brown¹⁷ reported two cases in females in their sixth decade of life with classic symptoms of salivary obstruction. The authors indicated that the primary duct, secondary ducts and obstruction(s) were easily identified in both cases. Although the diagnostic capabilities of CBCT sialography were not compared with any other form of imaging, radiation doses delivered to the patients were addressed. Using rough estimates, the authors concluded that CBCT sialography delivered a radiation dose equal to fluoroscopic sialography, but higher than plain image sialography.¹⁷ Our earlier work indicates that this may not be the case. Indeed, the choice of using lower peak tube potential (80 kVp) and milliamperage (10 mA) settings may lower the patient radiation dose (from 65 μ Sv using plain radiographs to 60 μ Sv using CBCT for the parotid gland and from 156 μ Sv using plain radiographs to 148 μ Sv using CBCT for the submandibular gland) without compromising image quality at all.^{6,7} Of note is that different iodine concentrations in the contrast agent were used for the two cases (300 mg I ml⁻¹ and 370 mg I ml⁻¹) and by observation, the authors concluded that a lower concentration of iodine (180 mg I ml⁻¹ or 240 mg I ml⁻¹) might have been better.¹⁷ This conclusion is in general agreement with our earlier *in vitro* work on image quality that demonstrated that the lowest commercially available iodine concentration (140 mg I ml⁻¹) is adequate for CBCT sialography.⁷

We achieved “moderate to very good” interobserver agreement in visualization of the normal gland structures

and in identifying abnormal findings as the three observers were all certified specialists in oral and maxillofacial radiology with extensive training in sialography and advanced imaging interpretation. The “fair to moderate” agreement for visualization of the parenchyma is not surprising since the parenchymal appearance can vary depending on many factors such as the degree of damage of the terminal acini, the amount of contrast injected and the amount of pressure used during injection. It is also encouraging that for interpretation, the interobserver agreement was greater for CBCT images than for plain images.

In conclusion, our results that are based on image interpretation indicate that CBCT sialography may be better than plain film sialography in visualizing the delicate structures of the parotid and submandibular salivary glands, identifying sialoliths and single ductal strictures, and differentiating normal salivary glands from those with secondary inflammatory changes.

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