


Computed Tomography Versus Dacryocystography for the Evaluation of the Nasolacrimal Duct—A Study With 72 Patients

Serafim Papathanassiou, MD[†]; Thomas Koch, MD[†]; Marie Charlot Suhling, MD; Thomas Lenarz, MD; Martin Durisin, MD; Stefan R. O. Stolle, MD[†] ; Peter Raab, MD[†]

Objectives: In patients with epiphora, imaging of the nasolacrimal duct is essential not only for differential diagnosis, but also for preoperative planning. Advances in imaging technology and introduction of cone beam computed tomography (CB-CT) enable the combination of contrast agent-based imaging with a three dimensional tomography with low radiation exposure. However, the value of CT/CB-CT as an alternative to conventional dynamic dacryocystography (DCG) has not been evaluated yet.

Study Design: Retrospective study.

Methods: Conventional DCG was performed preoperatively in 72 consecutive patients treated for epiphora between 01/2013 and 04/2015 in our department. CB-CT or conventional CT was performed afterward with the contrast media still in place. Three separate experts (two radiologists and one otorhinolaryngologist) analyzed the radiographic images without any information about the respective clinical or surgical findings. The presence of further findings in the CT/CB-CT (eg, septal deviation, sinusitis) that were not detected in DCG and the overall visibility of the lacrimal duct system in both modalities were evaluated.

Results: Good delineations of bone, soft tissue, and contrast agent in the lacrimal system were achieved with both methods. No side effects were noted. Beside the pathology of the lacrimal duct, CT/CB-CT scans enabled the additional diagnosis of pathologies in the nose and the sinus system in 65.7% of the patients. Accordance in the identified level of obstruction between the two modalities was achieved in 71.4% of the patients.

Conclusion: Thus, CT/CB-CT should be used in conjunction with contrast agent to reliably identify the level of obstruction as preoperative standard and can be used as diagnostic tool in addition to or even instead of conventional DCG.

Key Words: Cone beam computed tomography, conventional dacryocystography, epiphora, nasolacrimal duct.

Level of Evidence: 4

INTRODUCTION

The main purpose of the nasolacrimal apparatus is to provide adequate moisturization and lubrication of the cornea and the conjunctiva. It consists, therefore, of a secretory and a drainage part. Obstruction or insufficient drainage of the nasolacrimal duct causes epiphora and this is the most common complaint that leads the patient to the specialist's office. To adequately address this condition, a thorough diagnosis is of importance. Besides functional assessment in a physiological and nonphysiological setting,^{1,2} imaging of the nasolacrimal duct is the key for proper diagnosis and preoperative assessment. Conventional radiography with the use of contrast agent termed dacryocystography (DCG) with or without a dynamic examination or the possibility of digital

subtraction is hitherto the standard diagnostic tool.³ It seems the adequate method to recognize and to localize the obstruction of the nasolacrimal duct and to depict its anatomical course. Nevertheless, its ability to display information beyond that of the drainage lumen is very limited. A study in 1999 emphasized on several surprises during surgery of the lacrimal drainage system that could have been avoided by the use of proper diagnostic imaging of the surrounding structures prior to surgery.⁴ The authors analyzed more than 100 cases undergoing lacrimal drainage surgery by preoperative evaluation with computed tomography and found that most cases exhibited local nasal or sinus pathology that led to the obstruction of the lacrimal system. However, the authors did not recommend routine screening with computed tomography with respect to the increased radiation exposure. In the age of modern technology, the introduction of the cone-beam computed tomography allows detailed analysis of the nasal and paranasal spaces with lower radiation exposure dose when compared to standard conventional multi detector computed tomography (MDCT) protocols. A similar study of phantoms with dental implants suggests this conclusion,⁵ but optimization of MDCT-protocols can lead to low dose examinations comparable to cone beam computed tomography (CB-CT).⁶

Studies emerged to investigate if CT with DCG is a useful alternative to conventional DCG for the diagnostic evaluation of patients with epiphora. In combination with CT, DCG was considered to be a safe and time-efficient method for assessing the nasolacrimal duct system in patients with

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From the Department of Otorhinolaryngology, Head and Neck Surgery (S.P., M.C.S., T.L., M.D., S.R.O.S.), Hannover Medical School, Hannover, Germany; Radiologie im Silberturm (S.P.), St. Gallen, Switzerland; ENT-Surgery (T.K.), Hannover, Germany; Institute of Diagnostic and Interventional Neuroradiology (P.R.), Hannover Medical School, Hannover, Germany

[†]These authors are contributed equally to this study.

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Send correspondence to Stefan R. O. Stolle, Carl-Neuberg-Str. 1, 30625 Hannover, Germany. Email: stolle.stefan@mh-hannover.de

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epiphora.⁷⁻⁹ It provides detailed analysis of the nasolacrimal drainage system as well as the surrounding soft and hard tissue within one setting. Wilhelm⁸ analyzed in his study a total of 45 patients using the direct syringing technique for application of the contrast agent. He found significant lower dose levels on the eye lens with his technique in comparison with a standard CT of the midface. For a further reduction of radiation, Tschopp et al¹⁰ performed a DCG with a modern CB-CT, which can deliver very low doses of radiation onto the midface region.⁵

In Tschopp's investigation,¹⁰ 10 patients with epiphora were evaluated either with a passive technique for contrast medium application or with the direct syringing technique. The site of resistance was identified in all patients. The passive contrast medium application technique is used to be more sensitive since it also identifies patients with functional obstruction of the lacrimal system.¹⁰ Thus, this technique has been proven useful for the diagnosis of patients with epiphora prior to surgery.

The goal of the present study was to compare conventional DCG with MDCT/CB-CT (both with contrast agent still in place) in a larger cohort of patients with epiphora. To examine the conformity of DCG and MDCT/CB-CT images of the same area, three different experts (two radiologists and

an otolaryngologist) without any knowledge about clinical or surgical features of the patients delivered their assessments.

PATIENTS AND METHODS

The study was approved by the ethics commission of Hannover Medical School. The analysis was performed on 72 patients with epiphora who were evaluated by DCG and subsequent surgery. Inclusion criteria were age of 18 years or older, a volumetric scan (MDCT or CB-CT) with the contrast media still in place as well as endonasal dacryocystostomy. Patients evaluated only by DCG or DCG and CT (without contrast media) were excluded. The retrospective analysis was conducted in accordance to the guidelines of the World Medical Association Declaration of Helsinki.

All DCG procedures were performed with a flat-panel angiography system (Axiom Artis dBA, Siemens, Erlangen, Germany). All patients included in the study received a DCG and a subsequent MDCT/CB-CT. The patients were investigated lying in supine head position during the DCG. Local anaesthesia of the conjunctiva was performed. Catheterization of the inferior as well as superior punctum of the affected eye was achieved with a 0.016 inch polyvinyl microcatheter (Rabinov SCS-P-16-L, Cook Medical, USA). Thereafter, a

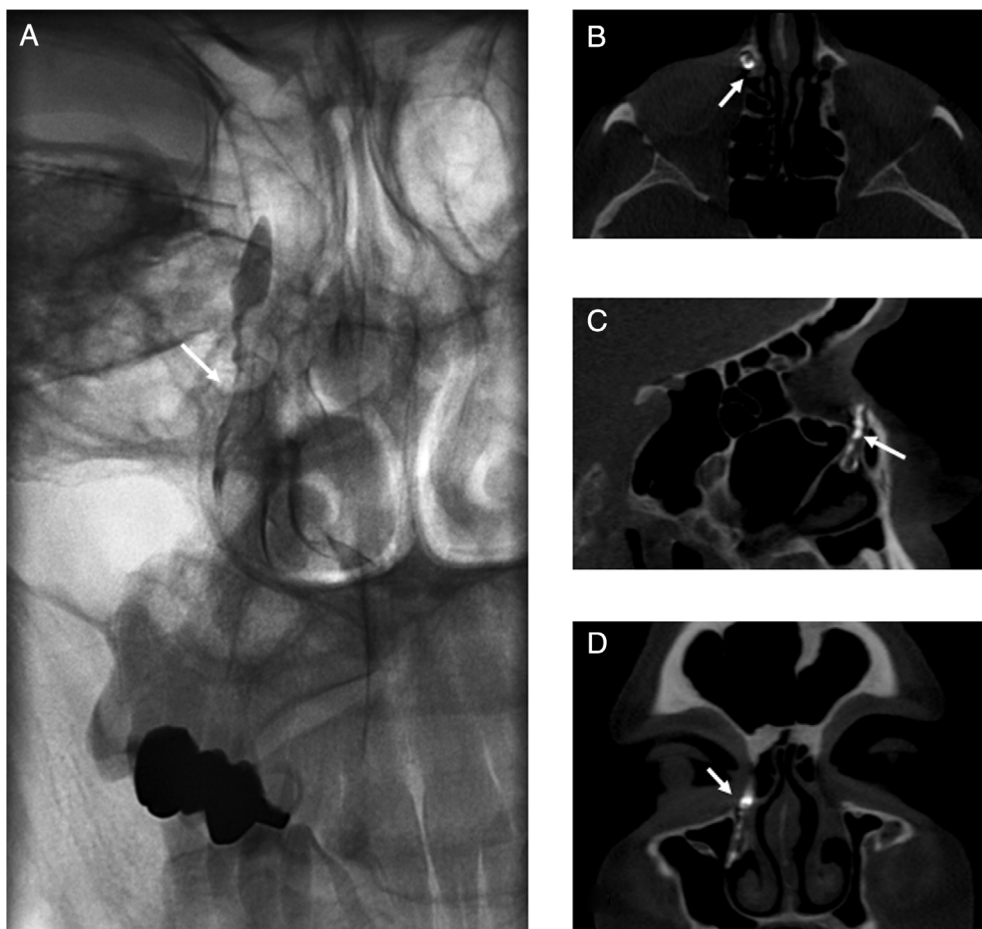


Fig. 1. Obstruction of the right lacrimal pathway by several stones (arrows) in the caudal part of the lacrimal sac and duct, slight deviation of nasal septum. (A) Dacryocystography; (B) cone beam computed tomography (CB-CT) axial; (C) CB-CT sagittal; and (D) CB-CT coronal.

slow injection of 1–2 mL of the nonionic, water-soluble contrast medium (Imeron-300, Bracco Imaging, Germany) was performed while acquiring the posterior–anterior DCG image series. Thereafter, MDCT/CB-CT was performed with the patient in a lying or sitting position, respectively. The acquired raw data were reconstructed in axial, coronal, and sagittal images.

Images were analyzed retrospectively by three blinded examiners (S.P. and P.R., radiologists and T.K., otolaryngologist), on a subjective level. Neither gender nor clinical information were known to the examiners. According to the DCG and MDCT/CB-CT images, the examiners first had to evaluate retrospectively the visibility of the structures of the lacrimal pathway (upper, lower and common canaliculi, saccus, ductus), and, if visible, the quality of their presentation (bad, good, excellent). Second, they had to look for further pathologic structures in the MDCT/CB-CT images (septal deviation, sinusitis, polyps, concha bullosa, Keros classification of olfactory fossa, surgical defects) and third, the level of obstruction in the lacrimal pathway had to be identified (canaliculi, saccus, ductus, inferior ostium at the level of the inferior turbinate) in both examination techniques. The results were analyzed and depicted using Graph Pad Prism.

RESULTS

A total of 72 patients were analyzed by two radiologists and an otorhinolaryngologist as listed above.

The visibility of the anatomical structures (examples: Figs. 1–3) was judged by all examiners for the volumetric scans and the DCG. The examiners agreed in more than 80% of the cases concerning information between the modalities (Fig. 4A). The cases with disagreement between the experts usually showed their differences only in the rating of the quality of the presentation, that is, between bad and good or good and excellent.

Pathologic structures in the lacrimal system (stenosis, occlusion, stones, fractures) in MDCT/CB-CT and DCG were determined with the same results by all examiners in 97.2% of the cases, in 2.8% (two patients), the judgment was different (Fig. 4B).

Concerning possible additional pathologies of the nose or the paranasal sinuses in the volumetric scans, all examiners agreed in 97.2% of the cases (Fig. 4B). The remaining 2.8% (two patients) confined cases with a possible slight difference (ie, a slight septal deviation that could be judged as pathologic or still in the normal range).

According to all examiners, additional pathologies were definitely found in the volumetric scans in 46 patients (66%)

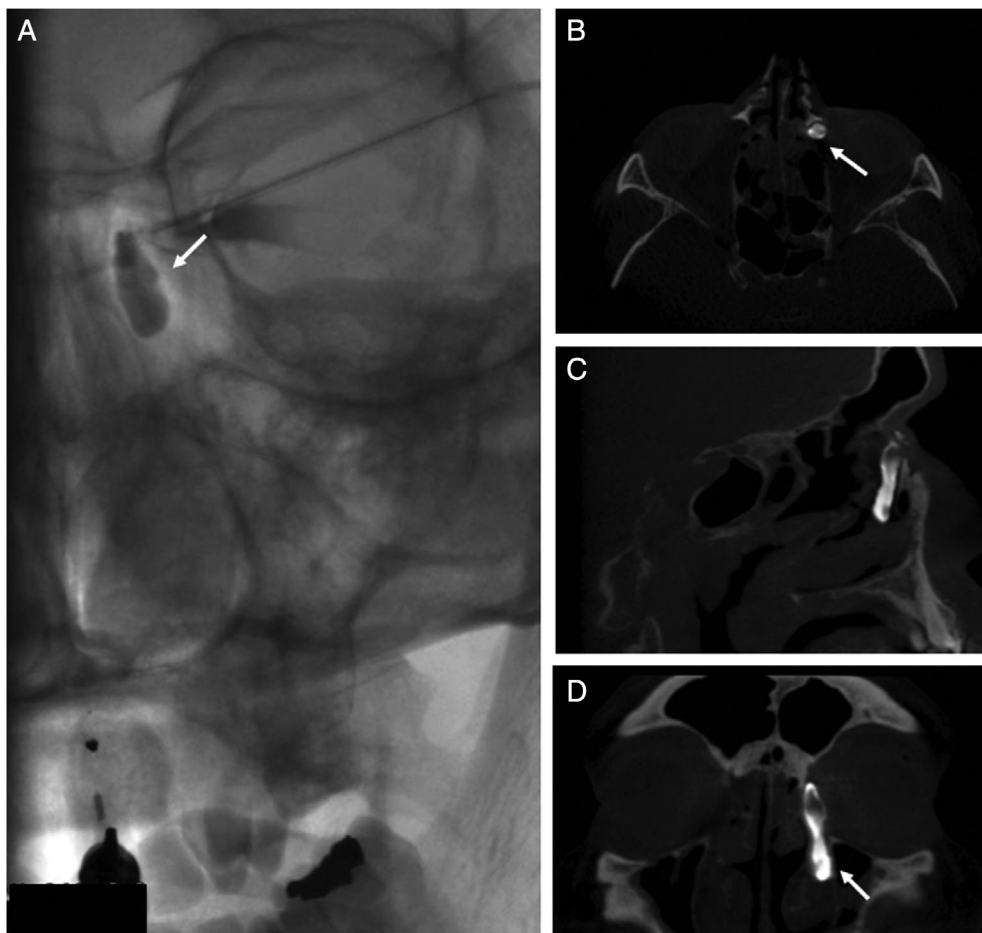


Fig. 2. Complete obstruction of the caudal lacrimal sac on the left side (arrow shows congestion), sinusitis of the ethmoidal cells on both sides. (A) Dacryocystography; (B) cone beam computed tomography (CB-CT) axial; (C) CB-CT sagittal; and (D) CB-CT coronal.

(Fig. 5). Among these, septal deviation ($n = 29$) was most common, followed by hypertrophy of the inferior turbinates ($n = 25$), Keros III classification of the olfactory fossa ($n = 24$), concha bullosa ($n = 23$), polyps ($n = 11$), and sinusitis ($n = 10$).

Concerning the level of obstruction of the lacrimal pathway, the experts agreed in 71.4% of the cases (50 patients) on the same level in DCG and volumetric scans. In 28.6% (20 patients), the level was different (Fig. 6).

Also for the judgment of the overall quality of the images, all examiners ruled in a similar way: in about 60% of the cases, the examiners assessed the DCG better concerning the visibility of the structures of the lacrimal system, whereas the volumetric scans offered the possibility of a better overview of the nearby structures of the nose and the paranasal sinuses.

DISCUSSION

In the present study, we evaluated the preoperative results of 72 consecutive patients with epiphora, who were referred to the ENT Department of our hospital for surgery of the nasolacrimal duct.

All examiners gained almost the same results in their tables after evaluation of all the acquired images (Figs. 4–6). This is a strong hint that both techniques,

correctly performed, deliver comparable images of the lacrimal pathway in a similar quality.

Concerning the level of obstruction, all examiners agreed on the same level between DCG and volumetric scans in 71.4% of the cases (Fig. 6), a similar agreement was reached concerning DCG and CT,⁶ DCG and magnetic resonance imaging (MRI),¹¹ and CT and MRI.¹² To detect and to localize a nasolacrimal obstruction, “DCG was considered to be the gold standard.”¹¹ Since meanwhile researchers agreed that the dosage of radiation in CB-CT can be lower compared to a standard MDCT⁸ in the investigation of the paranasal sinuses, the CB-CT might be favored in the diagnostics of nasolacrimal problems. In so far, the aim of this study was to find out if an additional volumetric CT scan with contrast of the nasolacrimal system could replace a classic DCG.

Although the level of obstruction as identified in the volumetric scans and in DCG was identical in 71.4%, in 28.5% of the cases, the localization of the lacrimal obstruction was completely different between the volumetric scans and DCG. This might be caused by the short time difference between both investigations, the difference in patient position and the transport of the patient, which could be responsible for a local shift of the contrast media. In the rest of the cases, the difference in the level of obstruction was localized into adjacent structures (ie, lacrimal sac vs. lacrimal duct). Overall, the

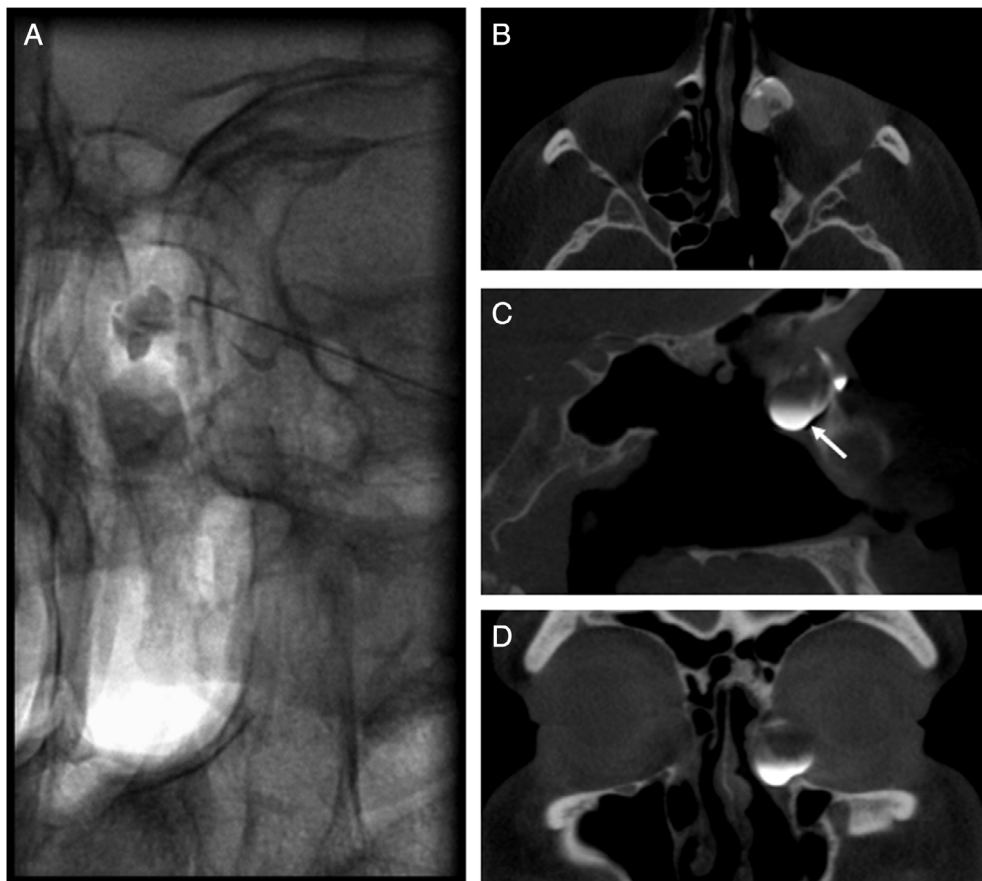


Fig. 3. Several stones in the left lacrimal sac (arrow), secondary occlusion of the sac following surgery of the ethmoidal cells and the lateral nasal wall on the same side. (A) Dacryocystography; (B) cone beam computed tomography (CB-CT) axial; (C) CB-CT sagittal; and (D) CB-CT coronal.

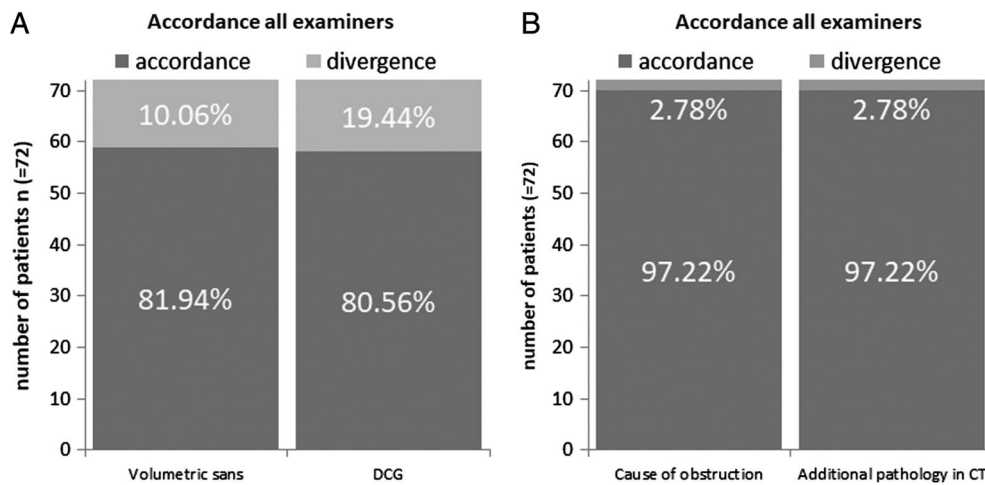


Fig. 4. Accordance of the presentation of the different structures of the lacrimal pathway by all examiners. (A) In the CB-CT and in the DCG (n = 72). (B) Cause of obstruction in the lacrimal pathway (eg, stones, stenosis) in DCG and CB-CT and the finding of additional pathology (septal deviation, sinusitis, concha bullosa, hypertrophy of conchae) in the CB-CT (n = 72). CB-CT = cone beam computed tomography; DCG = dacryocystography.

localization of obstruction was judged as consistent in more than 70% of the cases in the volumetric scans and DCG images.

According to the examiners, a significant portion of the patients (65.3%) included in the present study showed additional pathologies in the nose or the paranasal sinuses in the volumetric scan, which were not detected using DCG. These pathologies (septal deviation, hypertrophy of the turbinates, sinusitis, concha bullosa) can aggravate the symptoms of a lacrimal stenosis. At any rate, knowledge of these factors is useful for the planning of a surgical procedure.¹³ Francis et al⁴ demonstrated the importance of a preoperative CT to rule out pathologies in the nose and paranasal sinuses in a study with 107 cases of dacryostenosis.

All examiners agreed that the quality of presentation of the lacrimal system itself was superior in DCG compared to the volumetric scan. Nevertheless, the information about the reason of the obstruction (stones, stenosis) and the level of obstruction (canaliculi, lacrimal sac or duct) was sufficient with both techniques.

In terms of economic considerations, it has to be mentioned that the CB-CT scan is more expensive than

conventional DCG. According to the German federal health insurance association KBV-EBM, the DCG comes to €40.80 and the CB-CT (EMB number 34320) to €80.52. However, if the patient requires surgical intervention, a CB-CT scan has to be performed anyway as preoperative standard investigation. Thus, the costs for DCG and an additional CB-CT scan are higher than performing only a CB-CT with contrast agent for diagnosis and preoperative assessment.

An important advantage of the DCG over volumetric CT scanning is the dynamic investigation of the lacrimal system. The passage of the contrast agent can be observed by the investigator starting from the lacrimal punctae and throughout the whole system or until the passage stops at the point of the pathology. In this retrospective analysis, however, the judgment on the DCG was performed by analyzing static pictures instead of the dynamic investigation.

Despite the slightly better identification of the structures of the lacrimal duct system in DCG, a tomographic investigation of the midface, such as CB-CT or MDCT scan, is clearly superior in terms of the identification of

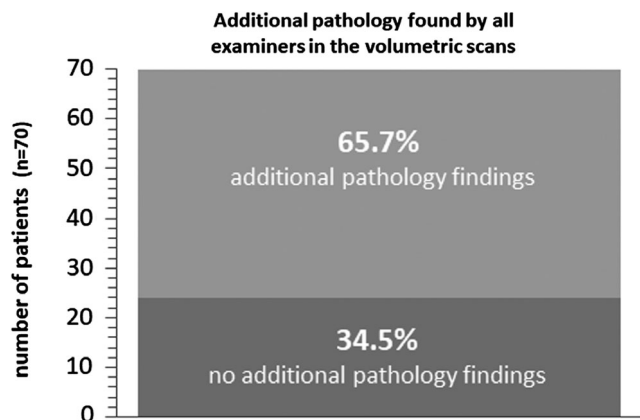


Fig. 5. Additional pathology found by all examiners in the cone beam computed tomography (n = 70). In two cases, the judgment was divergent (see Fig. 4B).

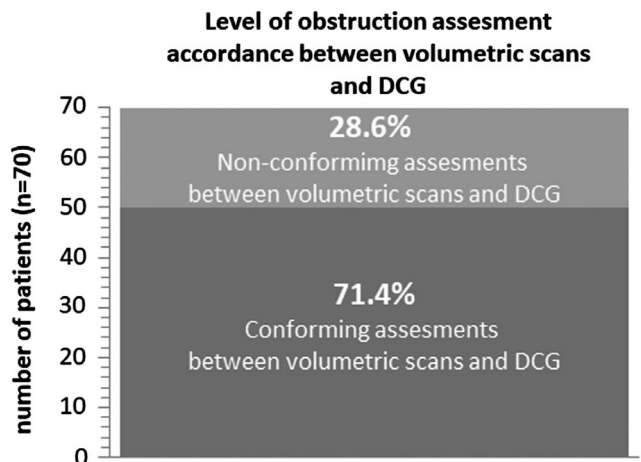


Fig. 6. Level of obstruction found in DCG and cone beam computed tomography by all examiners (n = 70). In two cases, the judgment was divergent (see Fig. 4B). DCG = dacryocystography.

further pathologies affecting the bony structures and the soft tissue of the nose and the paranasal sinuses, thereby aiding the planning of a surgical procedure.

The information about the lacrimal pathway in a tomographic scan with contrast media is sufficient for surgery and adequate information about nose and paranasal sinuses can be gained simultaneously. Therefore, a tomographic scan could be an alternative to classic DCG. However, this requires further investigation.

CONCLUSIONS

Based on the results of the present study, we could show that both techniques, DCG and volumetric CT scanning with contrast media, deliver images of the lacrimal pathway in a good quality. Since the information on additional pathology besides the lacrimal pathway, such as sinusitis, septal deviation, or nasal polyposis, is useful prior to surgery and can be better identified on tomographic CT images, a low dose tomographic scan with contrast media might therefore be an alternative to DCG in selected cases.

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