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## Possibilities and limits of imaging endodontic structures with CBCT

#### KEYWORDS

cone beam computed tomography (CBCT);  
 endodontics;  
 diagnostics;  
 two-dimensional X-ray diagnostics

#### SUMMARY

An adequate portrayal of the root canal anatomy by diagnostic imaging is a prerequisite for a successful diagnosis and therapy in endodontics. The introduction of dental cone beam computed tomography (CBCT) has considerably expanded the scope of imaging diagnostics. The aim of the following study was to evaluate the imaging of endodontic structures with CBCT. One hundred and twenty teeth were examined with a CBCT device (ProMax 3D). Subsequently, the findings of the three-dimensional images were evaluated and compared to those of dental radiographs and tangential section preparations of the examined teeth. Results with high prevalence, such as existing roots and root canals, as well as results

with low prevalence, e.g., extremely fine anatomical structures of the endodontic tissue, could be visualized precisely by dental CBCT; side canals, ramifications, communications, pulp stones, and obliterations could also be detected. Additionally, the length of curved root canals could be determined accurately. Likewise, root fractures were visualized reliably with CBCT. However, carious lesions could not be diagnosed adequately, and the evaluation of fillings and prosthetic restorations was complicated due to scattered X-ray artifacts. CBCT datasets qualify to visualize and diagnose small anatomical structures of the endodontic tissue.

#### Introduction

The number of endodontic treatments has risen significantly over the last decades due to the decreased number of extractions as well as improved methods of tooth restoration (FARRELL & BURKE 1989). Root canal treatment has become one of the most common measures of restoring teeth. If diagnosed and treated correctly, treatment success rates of 80 to 90% can be expected (FRIEDMANN 2002, HÜLSMANN 2005). However, treatment can be made more complicated by complex root canal

anatomy (FISCHER 1907, MEYER 1971), for instance, strongly bent canals, accessory and obliterated canals, pulp stones, or ramifications. Up to now, analog or digital two-dimensional intraoral single-tooth imaging has been an indispensable aid in clinical practice for planning and supporting therapy as well as monitoring treatment success. Yet, the information supplied by two-dimensional intraoral single-tooth imaging about complex three-dimensional root canal anatomy is quite limited. Especially concerning certain problems such as vertical

fractures or root resorption, the information is not conclusive (BRÄGGER ET AL. 2005, DOWKER ET AL. 1997). Since 1997, cone beam computed tomography (CBCT) has made its way into dental and oral medicine. Unlike taking a large number of two-dimensional cross-sectional images as in computer tomography (CT), dental CBCT – after acquiring an initial volume – reconstructs a set of three-dimensional data. Furthermore, CBCT exposes the patient to less radiation than CT (MOZZO ET AL. 1998, MÖBES ET AL. 2000, SCHULZE ET AL. 2005, ZIEGLER ET AL. 2002). Because CBCT has the ability to create precise, superimposition- and distortion-free images of structures, in dentistry it is most commonly used for oral surgery problems (ARAKI ET AL. 2007, COHENCA ET AL. 2007). High-resolution dental CBCT images are being increasingly applied in other areas of dentistry as well, such as periodontology, prosthetics, orthodontics, and endodontics (FLEINER ET AL. 2013A, FU ET AL. 2007, GANZ 2008, LOFTHAG-HANSEN ET AL. 2008). Other three-dimensional imaging techniques are also very promising in this field, e.g., flat-panel detector-based CBCT (HANNIG ET AL. 2006) and Tuned-Aperture Computed Tomography (TACT) (NAIR ET AL. 2001, NAIR ET AL. 2003). Admittedly, the application of said technology is currently limited to experimental and preclinical studies, because the devices either emit a relatively high level of radiation (HANNIG ET AL. 2006, HERRMANN ET AL. 2005), do not allow variable reduction of the X-ray beam volume (HAHN ET AL. 2009), require too much time for the scanning process (HANNIG ET AL. 2005, HEIDRICH ET AL. 2005, PETERS ET AL. 2000), or possess insufficient sensitivity and image quality (NAIR ET AL. 2001, NAIR ET AL. 2003).

Using micro computer tomography ( $\mu$ -CT), structures down to 20  $\mu$ m can be evaluated (BJØRNDAL ET AL. 1999, NIELSEN ET AL. 1995, PATEL ET AL. 2012, PETERS ET AL. 2003, RHODES ET AL. 2000). Due to the high dose of radiation, the small Gantry size, and the lengthy exposure time of up to a few hours,  $\mu$ -CT is only used *in vitro*.

The goal of this preclinical, experimental study was to examine the imaging of different endodontic findings using CBCT and define the indications for using CBCT in order to assess its limits more precisely. The results were evaluated by comparing them to two-dimensional single-tooth images and ground tangential preparations as the gold standard.

## Materials and methods

### Teeth

In the course of standard treatment at the Dental Clinic in Freiburg, 120 human teeth were extracted and submitted to the study anonymously (Tab. I). The incisors, premolars and molars were stored in a 1% thymol solution until examination and photographed for documentation. To insure exact reproducibility of the different imaging techniques, each tooth was imbedded in a resin block (Technovit, Heraeus Kulzer GmbH, Wehrheim, Germany).

### Two-dimensional imaging using single-tooth images

The digital radiographic images of the individual teeth were taken using a Gendex Oralix AC (Kavo Dental GmbH, Hamburg, Germany) with photo-stimulable phosphor plates measuring 2 × 4 cm (2+, D1415588, 2008-01, Dürr Dental AG, Bietigheim-Bissingen, Germany), then scanned using the VistaScan Perio system (Dürr Dental AG, Bietigheim-Bissingen) and exported as a TIFF file. The images of the objects to be tested were taken with the right-angle technique in a standardized format with a vestibular optical beam path and an optimum exposure dura-

**Tab. I** Anatomic distribution of the examined teeth

Type of tooth	Number
Maxillary anterior teeth	5
Mandibular anterior teeth	7
Maxillary canines	6
Mandibular canines	2
Maxillary premolars	9
Mandibular premolars	6
Maxillary molars	26
Mandibular molars	24
Primary teeth	20
Wisdom teeth	14
Gemination	1

tion of 0.26 seconds. The tube voltage was 65 kV with a tube current of 7.5 mA. A set distance between focus and object was insured by a fixture designed specifically for this experiment.

### Three-dimensional imaging with CBCT

The dental CBCT analysis of the teeth was done using the device ProMax 3D (Planmeca, Helsinki, Finland). A suitable jig of polytetrafluorethylene (PTFE) was made to hold the resin-embedded blocks in place. This insured a reproducible and invariable positioning of the objects to be tested in the CBCT device, and set a standardized distance between the source of the beam and the surface detector. Additionally, the positioning of the teeth was optimized by a laser light visor. For this study, an image resolution (voxel size) of 160  $\mu$ m was used. During the process of creating these CBCT images, a tube voltage of 82 kV and a tube current of 6 mA were used. By means of the 3D image capturing software, an object can be examined at the three relevant levels: axial, coronal, and sagittal, as well as from a rendered 3D perspective in the 3D imaging module. Furthermore, the quality of the image can be increased by image processing tools and with various features, such as angle and length measurement, additional evaluations can be done.

### Manufacture of the tangential section preparations

Finally, after taking the digital radiographs and CBCT images, the different root canal anatomies were visualized using a destructive method. For this purpose, each tooth imbedded in resin was tangentially sectioned using a wet-grinder (Knuth-Rotor-3, Struers, Willich, Germany) and sandpaper discs with various grit sizes (500, 800 and 1200). Then the tooth sections were polished (4000 grit) and digital microscopic photographs were taken. The ground tangential preparations served as a gold standard and were compared with the dental CBCT images.

### Method of data evaluation

The different radiological procedures (two-dimensional single-tooth imaging and dental CBCT) and the photographs of the

tangential sections were evaluated with regard to how well endodontic structures could be assessed. To ensure blinded examination, the two-dimensional single-tooth images, the dental CBCT as well as the photographs of the sectioned teeth were randomized by coding them with different numerical combinations. The examiners, two licensed dentists, were familiarized with the viewing programs and calibrated with exemplary images. While examining the images, both dentists always used the same computer and screen in a darkened room. Furthermore, they had the option of changing the size, brightness, and contrast of the radiographs.

Each examiner assessed one image per tooth and compared it to the gold standard. For instance, dentist "A" examined the two-dimensional single-tooth image of tooth No.1, and dentist "B" examined the dental CBCT of tooth No.1.

### Evaluated parameters

How well endodontic structures could be evaluated was documented in questionnaires designed for the study. Every parameter was assessed in both the two-dimensional single-tooth image and dental CBCT image. Afterwards, the findings were compared to the gold standard.

The following parameters were evaluated in this study: the number of visible roots and root canals of the individual teeth were evaluated making use of the different visualization possibilities the imaging techniques provided. Furthermore, the number of visible side canals was determined. This was to detect the presence of any accessory root canals that may be found in the root canal system of a tooth in addition to the number of root canals per tooth listed in literature. Thin branches of the main root canals (*ramifications*) and connections between the individual root canals (*communications*) were evaluated according to how well they were visualized using the different imaging techniques. Additionally, the continuity of the root canals as well as the possible occurrence of hard tissue appositions (*obliterations*)

inside the root canal were screened. Any *transverse* or *vertical fractures* were evaluated as horizontal or vertical discontinuities of the root.

The number of existing coronal *fillings* and *prosthetic restorations*, the sufficiency of their marginal seal, and the sufficiency (homogeneity, marginal seal, and completeness) of *root canal fillings* were also evaluated.

Along with making the distinction between enamel and dentin, and taking note of *artifacts* with the different imaging techniques, the extent of carious lesions was also evaluated.

### Radiographic measurements

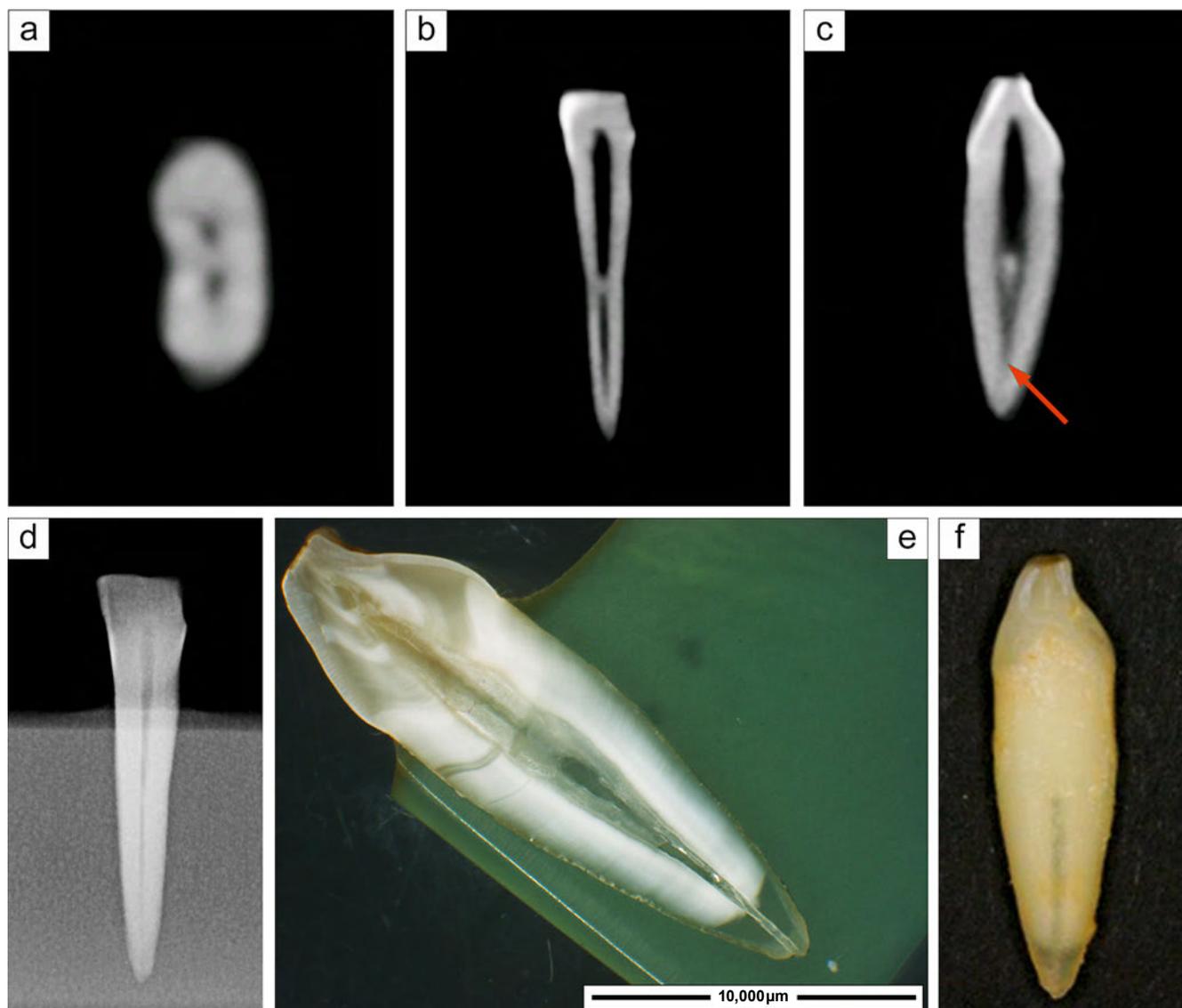
The required length of a root canal instrument (working length), which is a very important therapeutic parameter of root canal treatment, was taken into consideration when comparing the two-dimensional single-tooth image and dental CBCT image. In all 120 two-dimensional single-tooth images and 120 dental CBCT images, the distance between the roof of the pulp chamber and the physiological apical foramen of the root canal was measured. In the process, the working length according to the digital single-tooth images was determined using the DBSWIN 4.5 software (Dürr Dental AG, Bietigheim-Bissingen, Germany), and the working length according to the CBCT images was determined using the 3D image-capturing software for dental CBCT (Planmeca Romexis 3D Explorer, Planmeca, Helsinki, Finland).

### Statistical analysis

The findings of the evaluated parameters of both radiographic procedures (two-dimensional single-tooth imaging and dental CBCT imaging) were compared with the findings of the gold standard. For the evaluated parameter "radiographic measurement", the characteristic statistical parameters mean and standard deviation were determined as well as Pearson's correlation coefficient. Pearson's correlation coefficient ( $r$ ) quantifies the

Tab. II Total overview of the findings

Examined criteria	Gold standard	Two-dim. images	CBCT
	Correct findings in absolute numbers		
Number of roots	250	245	249
Root canals	295	230	294
Accessory canals	16	5	10
Root canal fillings	16	16	16
Transverse fractures	5	3	4
Vertical fractures	5	2	5
Ramification	43	26	41
Communication	20	7	19
Obliteration	4	3	4
Fillings	65	61	46
Caries	83	79	55
Artifacts	0	10	60



**Fig. 1** Mandibular anterior tooth with two root canals:

- a CBCT image in axial plane, two root canals are detectable
- b CBCT image in coronal plane
- c CBCT image in sagittal plane, root canal configuration type II, confluence shown by arrow
- d Single-tooth image in common vestibular-oral projection, only one canal is visible, relatively narrow canal lumen
- e Vestibular-lingual tangential-section preparation
- f Tooth viewed from a mesial perspective

strength of the correlation and describes the correlation of the radiographic procedures.

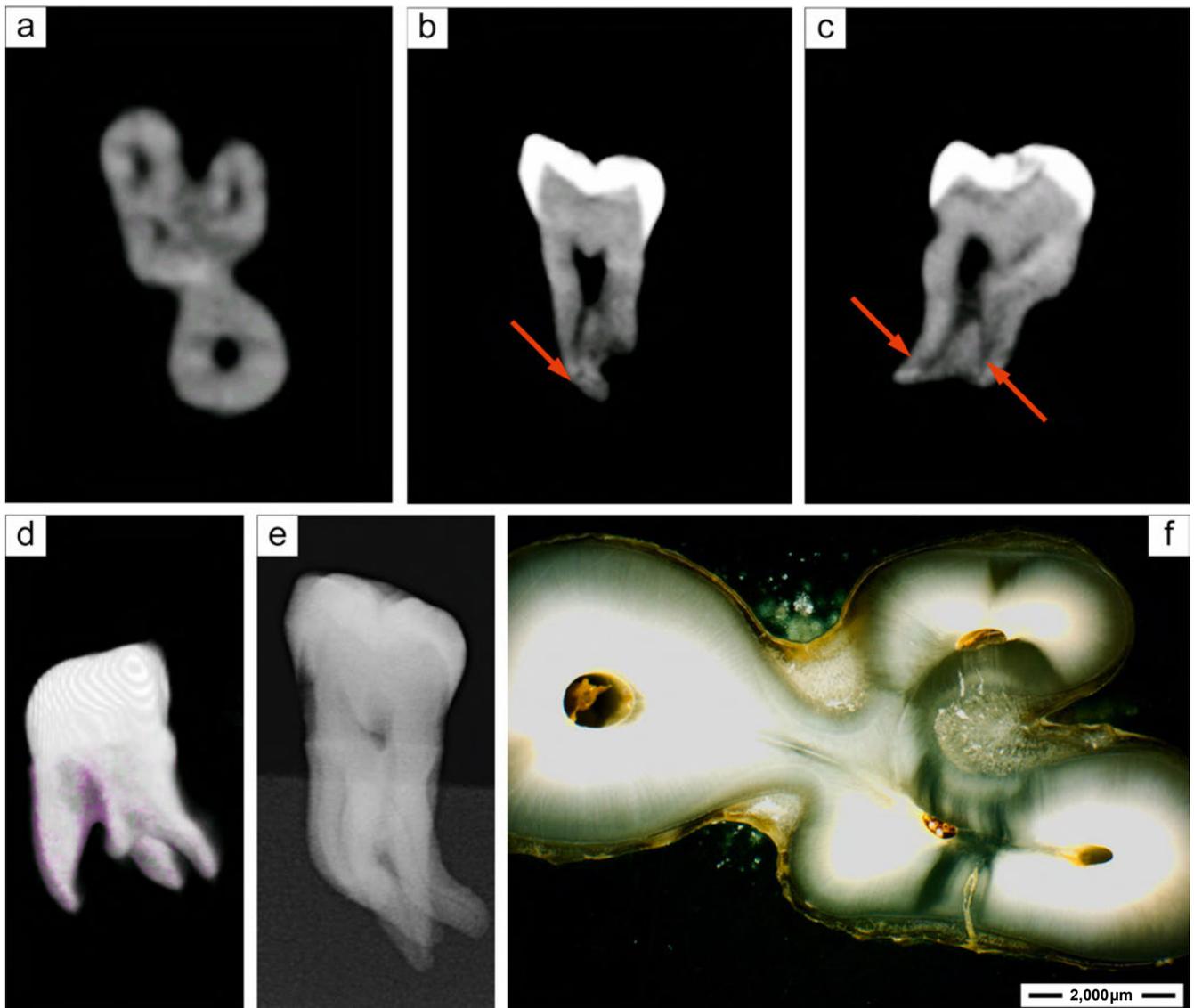
## Results

Using a checklist with set criteria, the results obtained from the 120 extracted teeth were compared to each other. There were advantages and disadvantages for both of the radiological procedures. A direct comparison of the two-dimensional single-tooth imaging and dental CBCT imaging is shown in Table II.

The three-dimensional image depicted the number of roots, root canals, and their configurations, ramifications and obliterations more clearly than did a two-dimensional single-tooth image. A good illustration of this is the finding (Fig. 1) of a mandibular anterior tooth with two root canals which could not be captured entirely in a single-tooth image. A similar example

is given in Figure 2, which shows a maxillary molar with an abnormal root canal and root canal anatomy. Only by using dental CBCT was it possible to obtain a complete overview of the tooth with its four-root morphology and complex root canal anatomy.

The gold standard set the number of visible roots at 250. Using dental CBCT imaging, 249 (99.6%) of the roots were identified correctly, and using the two-dimensional single-tooth imaging, 245 (98%) of the roots were found. When examining the number of root canals, of which a total of 295 were found by the gold standard, dental CBCT imaging recognized 294 (99%) and two-dimensional single-tooth imaging 230 (78%). Of the 16 side/accessory canals discovered in the gold standard, dental CBCT detected 10. Using two-dimensional single-tooth imaging, five accessory canals were identified correctly. It must be



**Fig. 2** Maxillary molar with an abnormal root canal and a complex root canal anatomy:

- a CBCT image in axial plane, four root canals are visible
- b CBCT image in coronal plane, accessory canal in the mesio-buccal root (arrow)
- c CBCT image in sagittal plane, imaging mb1 and mb2 with dentin surplus/overhang (arrow)
- d CBCT image in a rendered view, four roots can be detected
- e Single-tooth image in vestibular-oral projection, the four roots and four canals cannot be discerned clearly
- f Tangential-section preparation, apically-coronally ground image of the root canal system about 3 mm below the cemento-enamel junction

mentioned that two-dimensional single-tooth imaging yielded seven false positive results. This did not occur when using dental CBCT.

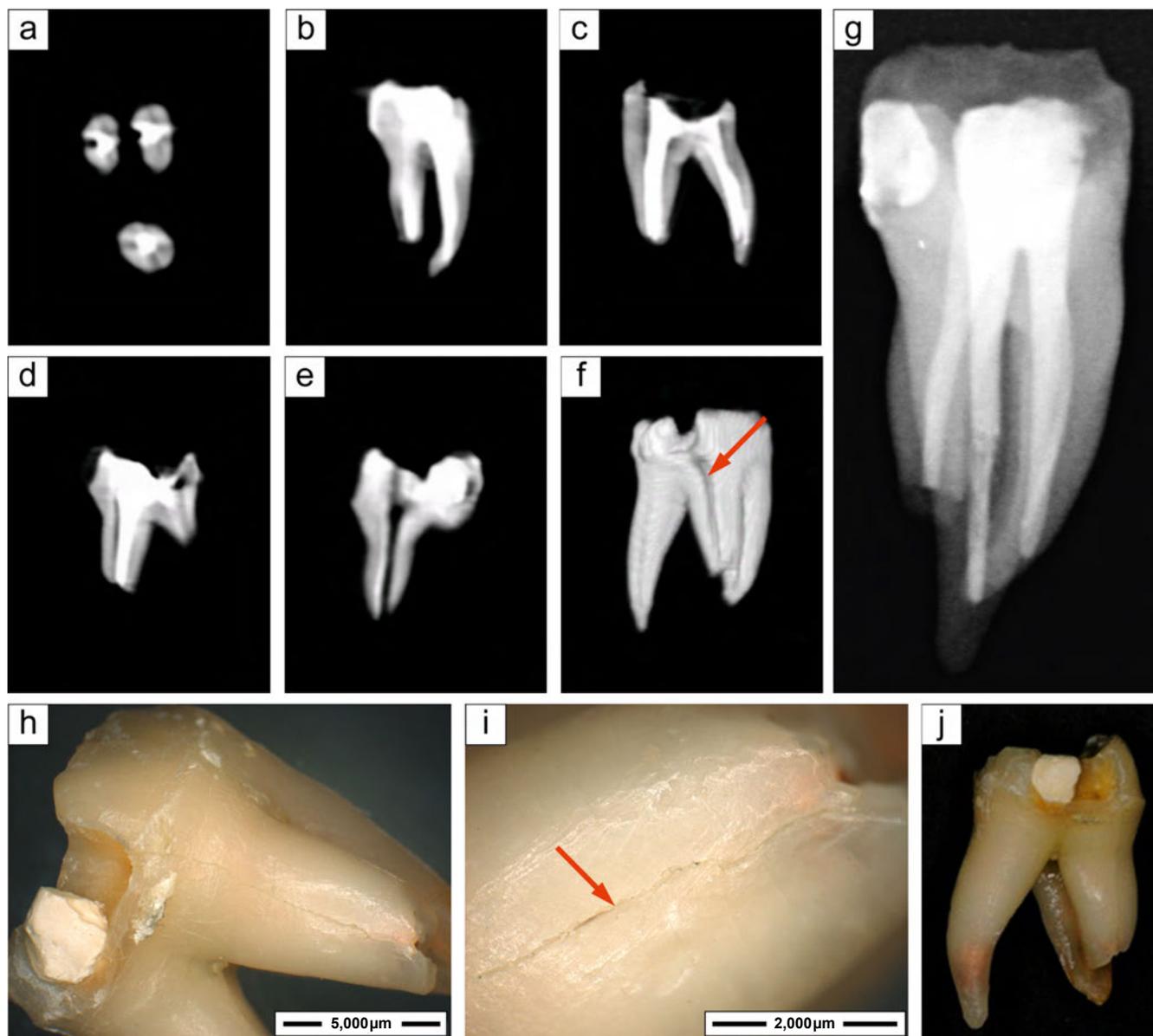
Concerning the length measurement of the root canals, the correlation coefficient ( $r$ ) was 0.915, which indicates a strong correlation between the measurement of length using dental CBCT imaging and two-dimensional single-tooth imaging.

In terms of transverse fractures, four of the existing five were detected by dental CBCT. Using two-dimensional single-tooth imaging, three of the five transverse fractures were found. 100% of the vertical fractures identified in the gold standard were also detected by dental CBCT. In the two-dimensional single-tooth image, only two of the five vertical fractures found in the gold standard were identified. The findings in Figure 3 show a maxillary molar with a vertical fracture and the condition after an

apical resection. However, the vertical fracture of the mesio-buccal root is not evident in the two-dimensional single-tooth image.

It was possible to diagnose existing root fillings with both dental CBCT imaging and two-dimensional single-tooth imaging. The assessment of the quality and sufficiency of the root fillings was, however, made more difficult by artifact formation of the root filling material when using tomographic datasets, and could only be done adequately with two-dimensional single-tooth images.

Likewise, metallic restorations also diminish the quality of dental CBCT images. Figure 4 shows a tooth with an amalgam filling, which led to artifact formation in the dental CBCT images and significant limitation in the evaluation of the images. Metal pins in root canals also resulted in artifacts, thus compli-



**Fig. 3** Maxillary molar with a vertical fracture, condition after apical root resection:  
 a CBCT image in axial plane, three canals with root fillings are detectable, quality of the root canal fillings cannot be evaluated sufficiently  
 b/c CBCT image in coronal plane  
 d/e CBCT image in sagittal plane  
 f CBCT image in a rendered view, vertical root fracture of the mesio buccal root, condition after apical root resection (arrow)  
 g Single-tooth image, insufficient root filling  
 h-j Digital pictures, vertical root fracture (arrow)

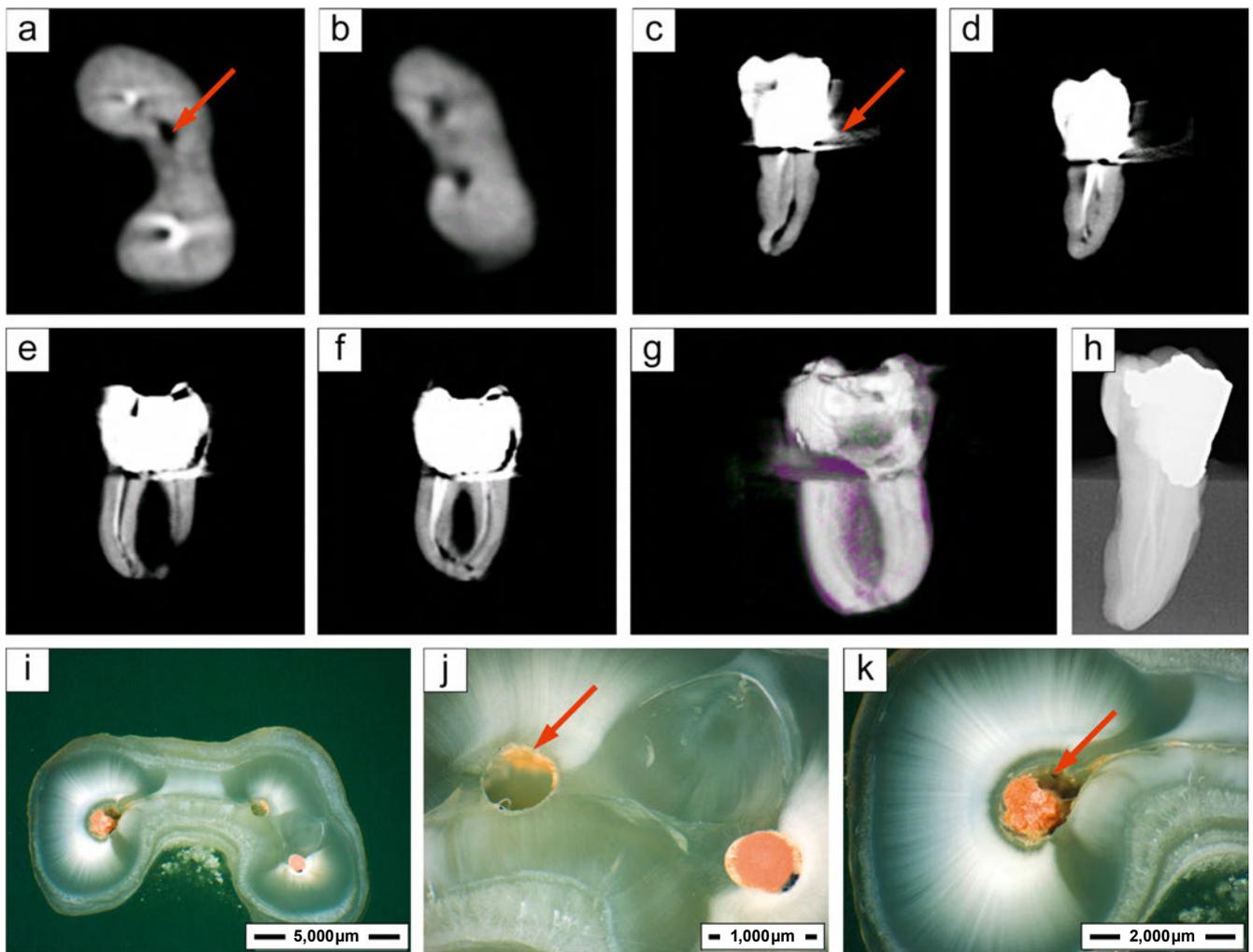
cating the diagnostics (Fig. 5). On the other hand, metal pins did not lead to artifacts in the two-dimensional single-tooth images.

Dental CBCT was able to correctly identify the length of the root canals and the length of the accessory canals of all the examined root canals, information which is absolutely necessary for endodontic treatment.

Softened, denatured, and demineralized carious hard dental tissues appeared as a black area on the dental CBCT images, depending on their size. Of the 83 carious lesions diagnosed in the gold standard, only 55 (66.3%) of the lesions were correctly identified in the dental CBCT images. Using two-dimensional single-tooth imaging, however, 79 (95.2%) of the carious

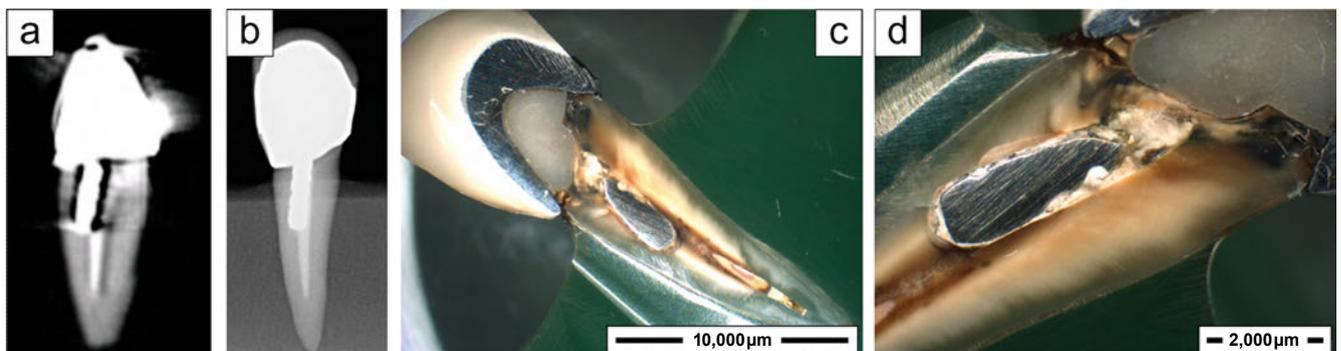
lesions could be visualized. An exact evaluation of the carious lesions was not possible using dental CBCT, whereas the extent of demineralization and the severity of the caries could be diagnosed precisely with the two-dimensional single-tooth images.

The occurrence and extent of any additional dentin structures, i.e., pulp stones, were hard to see in the two-dimensional single-tooth images. Figure 6 shows a maxillary molar with pulp stones in the pulp chamber. In the two-dimensional single-tooth image, two of the three pulp stones were detected. All three of the pulp stones were recognizable in the dental CBCT image. Furthermore, with the coronal- and sagittal-plane sections, it is possible to determine the size of the pulp stones in the dental CBCT image.



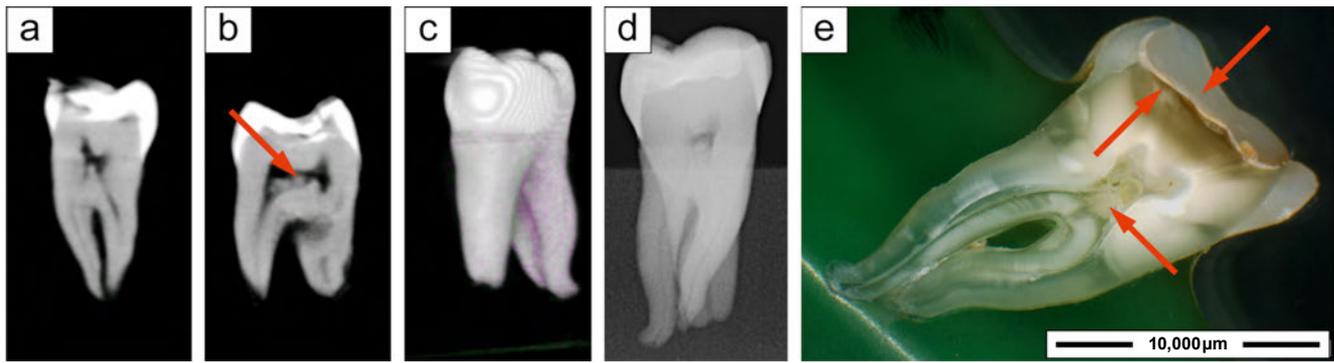
**Fig. 4** Mandibular molar with three root canals and an insufficient root filling:

- a CBCT image in axial plane, three root canals visible, two root canals have a root canal filling (untreated root canal is marked)
- b CBCT image in axial plane, both root canals contain no filling material
- c/d CBCT image in sagittal plane, inclusions of air between root filling and canal wall, artifacts of the coronal restoration (arrow)
- e/f CBCT image in coronal plane, c-shaped mesio-lingual and distal canal, quality of filling cannot be evaluated due to artifacts
- g CBCT image in a rendered view, artifacts caused by fillings
- h Single-tooth image, neither number of roots nor the root canal system is discernable
- i-k Photographs of tangential-section preparations, apically-coronally ground, root filling in distal and mesiolingual canal is not marginally sealed, insufficiently condensed (arrow in Fig. k), remnants of root filling material in mesiobuccal canal (Fig. j)



**Fig. 5** Maxillary anterior tooth with post-core buildup:

- a CBCT image in sagittal plane, root filling of the central canal seems too short, post deviates towards the vestibular from the original axis of the root canal, sufficiency of prosthetic restoration cannot be evaluated due to artifacts
- b Single-tooth image, root filling insufficient, post aligned with axis
- c/d Photographs of tangential-section preparations, ground from buccal to oral plane, perforation of the buccal canal wall caused by pin, marginal seal of crown is insufficient, carious lesions can be detected



**Fig. 6** Maxillary molar with pulp stones:

a CBCT image in coronal plane

b CBCT image in sagittal plane, pulp stones in crown pulp adherent to pulp chamber floor (arrow)

c CBCT image in a rendered view

d Single-tooth image, root canal anatomy and pulp stones cannot be clearly differentiated

e Tangential-section preparation, image of pulp stones in the crown pulp, visualization of composite resin filling with secondary caries (arrows)

## Discussion

In this preclinical, experimental study, the ability to depict root canal anatomies using two-dimensional single-tooth imaging and dental CBCT imaging was evaluated and compared. Additionally, a comparison with tangentially sectioned preparations of the examined teeth was conducted.

During the evaluation of the standardized two-dimensional single-tooth images, it has to be kept in mind that the *in vitro* images of the extracted teeth do not reflect the physiological situation. Specimen positioning for the imaging process was standardized by fixating the specimens in a special jig on the radiographic device, making it reproducible. Thus, motion artifacts, object distortions, and additional superimpositions of the teeth by adjacent structures and soft tissue (PATEL ET AL. 2009), as is always the case under *in vivo* conditions, were prevented.

As the gold standard for detection of specific anatomic root canal systems, tangentially sectioned ground preparations were made. However, this was a destructive two-dimensional process that only allowed the visualization of certain anatomic features.

Using dental CBCT, it is possible to reconstruct the tooth's entire soft-tissue core (endodont) and surrounding structures. The possibilities of reconstruction on the sagittal, axial, and coronal planes make the analysis of specific structures from different directions possible. By using dynamic image interpretations/findings, the full length of the tooth can be checked for pathological findings on all three spatial planes. On the other hand, when using two-dimensional single-tooth imaging, the problem of superimposition of root canals often occurs, especially with teeth with multiple roots. In such cases, a diagnosis is generally only possible with eccentric single-tooth images, which can still have superimpositions of their own, often do not show the entire root canal system, and require a trained eye (HÜLSMANN 2008, RHODES ET AL. 1999).

Root canal treatments of teeth with difficult canal configurations that deviate from the norm still pose a diagnostic and technical challenge. Capturing all the canal structures and removing the entire nerve tissue is essential for endodontic treatment. Parts of the canal that are overlooked and thus not treated repeatedly lead to reinfection and failure (LIN ET AL. 1991, SIQUEIRA ET AL. 1997, TANEJA ET AL. 2010). Conventional and digital two-dimensional single-tooth imaging techniques struggle

with capturing accessory canals, communications, ramifications, and fractures (KOTTOOR ET AL. 2010). In this study, however, dental CBCT was able to reliably detect the smallest anatomical structures of the endodont, such as root canals, accessory canals, communications, obliterations, and pulp stones. Additional studies confirm these results, and they further show that the use of dental CBCT imaging for the diagnosis of root resorptions, perforations (via falsa), and apical periodontitis is advantageous (BALL ET AL. 2013, BLATTNER ET AL. 2010, KOTTOOR ET AL. 2010, LIANG ET AL. 2011, MICHETTI ET AL. 2010, PATEL ET AL. 2012, SHEMAH ET AL. 2011, YOSHIOKA ET AL. 2011, YOUNG 2007). Furthermore, dental CBCT is an innovative diagnostic procedure, which enables determination of particular endodontic characteristics, such as c-shaped root canals, *radices entomolares*, and invaginations, as well as third mesial root canals in the mandibular molars (ABELLA ET AL. 2011, DURACK & PATEL 2011, LA ET AL. 2010, ZHENG ET AL. 2011).

In addition, it was possible to determine the exact length of curved canals, communications, and accessory canals using dental CBCT in this study. Other studies also describe determining the length and position of fractured root canal instruments (ARNOLD 2011, D'ADDAZIO ET AL. 2011) as well as the precise assessment of the position and extent of unwanted shoulder preparations when using dental CBCT (YOUNG 2007).

The high resolution as well as the precise overview and imaging of neighboring structures provided by dental CBCT made it possible to recognize fractures early on (EDLUND ET AL. 2011, FLEINER ET AL. 2013B, HANNIG ET AL. 2005, HASSAN ET AL. 2009). In this study, 100% (n=5) of the vertical root fractures and 80% (n=5) of the horizontal fractures could be diagnosed by using dental CBCT imaging. Using two-dimensional single-tooth imaging, two of the five vertical root fractures and three of the five horizontal fractures were visualized.

The studies by OZER (2010) and WANG ET AL. (2012) confirmed these results. They prove that, in terms of fracture recognition, dental CBCT imaging is superior to two-dimensional orthoradial single-tooth imaging. However, the Nyquist theorem has to be considered when evaluating the results at hand. It states that only structures that are larger than two voxels can be depicted. Should a fracture gap be smaller than that, it cannot be discerned in some cases (FLEINER ET AL. 2013B). Furthermore,

using dental CBCT, it is hard to diagnose transverse fractures in teeth with existing root fillings (HASSAN ET AL. 2009). In a study by PATEL ET AL. (2013), the artifacts caused by gutta-percha resulted in a misinterpretation of vertical fractures. Only 57% of the existing transverse fractures could be diagnosed with dental CBCT. In comparison, the two-dimensional single-tooth images had higher specificity but lower sensitivity than the dental CBCT when it came to evaluating existing transverse fractures.

On the other hand, carious lesions can be more readily diagnosed using two-dimensional single-tooth imaging. In this study, merely 66.3% (n=83) of the existing carious lesions were detected by dental CBCT. A study by ZHANG ET AL. (2007) confirmed these results, and claims that due to artifacts caused by metal restorations or the hard tooth structure, the diagnosis of proximal caries is hardly possible (RITTER ET AL. 2009). However, a study by HAAK ET AL. (2006) showed that, using the conventional bitewing technique, just 29% of the lesions were evaluated correctly in terms of their severity (depth of the lesion, caries diagnosis). In contrast, dental CBCT imaging proved to have a sensitivity of 80% with a specificity of 96% when diagnosing proximal caries. It was also shown that carious lesions with or without cavitation in the dentin are very easily discernable in dental CBCT images. Only the differentiation of discontinuities in the enamel posed difficulties (HAAK ET AL. 2006). However, VALIZADEH ET AL. (2012) reported that dental CBCT imaging, compared to conventional two-dimensional single-tooth imaging, does not lead to improved diagnostics of proximal carious lesions.

In most cases, dental CBCT imaging offers more extensive diagnostics than two-dimensional single-tooth imaging (JACOBS 2011), although 3D imaging exposes the patients to more radiation. According to German Radiographic Regulations (2002) § 23, a justifying indication is necessary for every image, and every diagnostic problem is to be processed with the smallest possible effective dose. When using two-dimensional single-tooth imaging, an average effective dose of 4–8 µSv must be assumed (OKANO ET AL. 2009). The effective dose when using dental CBCT depends on the type of machine used, the examination volume, and especially on the duration of exposure needed to create the desired image. For a dental CBCT image with a medium FOV (field of view), the patient is exposed to an average effective dose of between 69 and 560 µSv (LUDLOW & IVANOVIC

2008). Thus, the health benefit to the patient should always outweigh the danger posed by the use of X-rays (§ 23 RöV). Due to a lower exposure to radiation in dental CBCT than in CT, the areas of indication are spreading to the different branches of dentistry. The guideline “CBCT” of the German Society for Dental and Oral Medicine (DGZMK) from April 6, 2009 defines indications and fields of application for CBCT in orthodontics, periodontology, endodontics, implantology, and in diagnosing TMJ disorders (HONEY ET AL. 2007, VANDENBERGHE ET AL. 2007). In endodontics, the guideline “CBCT” recommends the CBCT to be used for apical alterations if their extent is not obvious in the two-dimensional single-tooth image, and in cases of suspected root fractures and resorptions (DGZMK 2009).

The multiple techniques of visualization offered by dental CBCT lead to a shorter and more optimized therapeutic procedure in difficult endodontic cases.

## Résumé

Une présentation appropriée de l'anatomie du canal radiculaire avec des procédés d'imagerie est la condition préalable à un diagnostic et traitement endodontique réussis. Le lancement de la tomographie volumique à faisceau conique (TVFC) a permis d'élargir le spectre du diagnostic par l'imagerie. Cette étude vise à évaluer la représentation de structures endodontiques avec la TVFC. 120 dents ont été examinées avec la TVFC (ProMax 3D). Les résultats des clichés tridimensionnels ont été comparés aux radiographies bidimensionnelles et aux préparations sectionnelles transversales des dents examinées. La TVFC permet de visualiser de façon précise les résultats avec une forte prévalence comme des racines et des canaux radiculaires aussi bien que les résultats avec une faible prévalence comme les structures anatomiques fines; des canaux latéraux, des ramifications, des communications, des denticles et des oblitérations ont pu être détectés. En plus, la longueur des canaux déjetés est déterminée exactement. La TVFC a pu également montrer des fractures radiculaires. Mais elle n'a pas donné d'information suffisante concernant les lésions carieuses et en plus l'appréciation d'obturations et de reconstructions prothétiques est entravée par des artefacts.

La TVFC est appropriée pour la visualisation et le diagnostic de petites structures du tissu endodontique en 3D.

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