RESEARCH ARTICLE

Marginal bone loss and resorption of second molars related to maxillary third molars in panoramic images compared with CBCT

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Objectives: Compare findings among observers in panoramic images (PAN) and cone beam CT (CBCT); and assess findings in PAN as indicators for marginal bone loss and resorption observed in CBCT.

Methods: 120 impacted maxillary third molars with PAN and CBCT were included. Four observers assessed morphological features: (1) tooth angulation; (2) number of roots; (3) bony impaction (yes/no) and pathology; (4) marginal bone level at the second molar (normal/ >3 mm = bone loss); (5) resorption in the second molar (no/superficial/ $<$ half way through the dentin/ $\geq$ half way through the dentin/involving the pulp); (6) size of follicular space (normal/ >4 mm(cyst)). Percentage accordance and κ statistics described observer variation in PAN and CBCT. Logistic regression analyses tested findings in PAN as indicators for marginal bone loss or resorption observed in CBCT.

Results: κ values were fair and interobserver accordance was marginally higher in CBCT than PAN. Agreement between PAN and CBCT was 81–88% for marginal bone loss and 68–81% for resorption. Severe resorption was more often observed in CBCT. Mesio-angulated third molars and marginal bone loss interpreted in PAN significantly indicated marginal bone loss observed in CBCT (odds ratio 17–34; $p < 0.012$; 8.8–52.8; $p < 0.02$). In contrast, findings in PAN were not significant indicators for resorption observed in CBCT ($p > 0.05$).

Conclusion: In general, there was a fair agreement for marginal bone loss between PAN and CBCT, and PAN could significantly predict bone loss observed in CBCT. However, presence of resorption observed in CBCT could not be determined from PAN, and more severe resorption was observed in CBCT. CBCT is indicated if resorption in the second molar needs to be assessed.

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Introduction

In Western populations, the third molar is the tooth, which is most frequently impacted.¹ A study based on panoramic images (PAN) of the adult Finish population found an impaction rate of 27% for third molars in general.¹ Furthermore, pathologies and anomalies related to third molars occurred in 47% of the adult

population assessed either clinically or radiographically.¹ According to the NICE guidelines, irreversible pathology (e.g. marginal bone loss and resorption of the second molar or a cyst in relation to the third molar) related to an impacted third molar is indicative for a removal of the tooth in question.² Before removal of a tooth, a radiographic examination is needed. PAN may be the first-choice radiographic method for establishing a diagnosis prior to treatment decision of an impacted

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third molar,³ while cone beam CT (CBCT) offers the possibility of a three-dimensional view. Evidence-based guidelines for when to perform a CBCT examination are, however, needed due to the larger radiation dose and higher costs for the patient and the society.⁴

Fryback and Thornbury (F&T) have suggested a hierarchical model of how to provide evidence for the impact of a diagnostic imaging method.⁵ The model operates with six levels of efficacy to be taken into consideration when a new imaging modality is to be introduced. During the past decade, several research groups have investigated the use of CBCT before surgical intervention of mandibular third molars.^{6,7} Conclusively, studies at all six levels of efficacy are available, which have shown that CBCT does not change the outcome for the patient when compared with PAN.^{6,7}

On the other hand, studies on the use of CBCT for maxillary third molars are missing. Like mandibular third molars, maxillary third molars can be associated with pathology, which often leads to removal of the tooth.² It can be speculated that assessment of pathology in PAN of third molars can be more difficult in the upper than in the lower jaw due to overprojection of the maxillary sinus, the zygomatic bone, and the second molar, and therefore PAN may not provide adequate visualization of the maxillary third molar region. Possibly, CBCT could add important information allowing the surgeon to establish the correct diagnosis and subsequently plan the treatment. Studies currently available on the use of CBCT for maxillary third molars have reached F&T-level 2 and 3 according to the hierarchical model of efficacy assessing the accuracy of the method.^{8–12} Previous studies at Level 2 investigated the angulation and impaction depth of impacted maxillary third molars in both PAN and CBCT.^{8,9} Both studies found that buccal inclination was the most common position in the transversal plane. Additionally, one of the studies⁹ stated that the vertical position was the most frequent position in the sagittal plane whereas the other study⁸ found that the distal position was the most common. Studies related to pathologies are sparse, and only a few have evaluated resorption in the distal surface of the maxillary second molar,^{1,12,13} which may be a determining factor for treatment decision.² The results are diverse since one study at F&T-Level 3 found that resorption was more often diagnosed in CBCT than in PAN assessed by two observers,¹² another study did not report the amount or degree of resorption,¹ and the third study did not observe any resorption of the second molar related to impacted maxillary third molars.¹³

The aim of this study was to compare findings of marginal bone loss and resorption of the distal surface of the second molar and increased follicular space related to the third molar in PAN and CBCT performed for treatment planning of impacted maxillary third molars. Further, to assess marginal bone loss and resorption of the distal surface of the second molar in the PAN as indicators for findings in CBCT, *i.e.* whether findings in

Table 1 An overview of the indications for referring to a CBCT - some cases had more than one indication

<i>Indication for CBCT</i>	
Suspicion of resorption	98
Suspicion of cyst	5
Suspicion of marginal bone loss	2
Assessment of roots	4
Problems in eruption of the second molar	2
Assessment of tooth morphology	2
Assessment of the relation to the maxillary sinus	5
Assessment of supernumerary tooth in third molar region	4

CBCT, cone beam CT.

PAN are able to predict subsequent findings observed in CBCT. Moreover, interobserver reproducibility for both imaging modalities was investigated.

Methods and aterials

Radiographic examination

This retrospective study included a total of 93 patients (28 males and 65 females) with 120 impacted maxillary third molars. Mean age was 26 years (ranging from 15 to 55 years). Between 2010 and 2017, the patients were referred either from private practice, community dental healthcare clinics, or Section of Oral Surgery and Oral Pathology, Department of Dentistry and Oral Health to the Section of Oral Radiology, Department of Dentistry and Oral Health, Aarhus University, Denmark. All patients were referred to CBCT based on suspicion of pathology or anomaly in relation to an impacted maxillary third molar registered in a PAN (Table 1).

A PAN was either achieved from the referring practice or performed in the Section of Oral Radiology using a ProMax unit (Planmeca, Helsinki, Finland) with a CCD-based image receptor. To reduce radiation dose, the recording was sectioned to expose only the area of the third molar(s) in question.

CBCT examination was performed with a Scanora 3D unit (Soredex, Helsinki, Finland) with a 6 × 6 cm field of view (FOV) and 0.13 mm voxel resolution. The FOV was centered at the maxillary third molar region. Only patients who had CBCT performed no more than 3 months after the PAN were included in the study. All patients were treated based on findings in the CBCT.

Radiographic assessment

The PAN and CBCT volumes were assessed in a random order by four observers (Observer 1, 2, 3, and 4) on two separate occasions with at least 1 month between PANs (first scores) and CBCTs (second scores). Three experienced oral radiologists and one pre-graduate dental student served as observers. The three oral radiologists had several years of experience evaluating CBCT while the pre-graduate student was taught how to navigate the CBCT software by one of the three radiologists.

Moreover, the four observers were calibrated in sessions assessing 20 cases not included in the study. During the calibration sessions, also magnification in PAN was discussed. The PAN and CBCT volumes were assessed on 24-inch, high-resolution monitors in a dimmed light room. The CBCT volumes were assessed in OnDemand software (Cybermed Inc. Irvine, CA). The observers had the possibility to use enhancement filters as they preferred, for the study to be most comparable to a normal clinical setting.

The parameters evaluated were the same for PAN and CBCT: morphological parameters (1) tooth angulation relative to the long axis of the maxillary second molar (vertical/mesio-angulated/disto-angulated/horizontal/inverted/transversal)¹⁴; (2) number of roots (1/2/3/4/ >4); (3) bony impaction (yes/no) and pathological parameters; (4) marginal bone level at the distal surface of the second molar, *i.e.* the distance from the cemento-enamel junction to the most coronal alveolar bone (normal 1–3 mm/bone loss (a marginal bone level located >3 mm from the cemento-enamel junction was considered bone loss)); (5) resorption in the distal surface of the second molar (no/superficial/<half way through the dentin/≥half way through the dentin/involving the pulp); (6) increased follicular space >4 mm interpreted as presence of a cyst (yes/no). 20 randomly selected cases (17% of the study material) were assessed twice by all observers to assess intraobserver reproducibility.

Data treatment

Data were recorded in separate PDF files (Adobe Acrobat Reader DC, Ireland Ltd) for both imaging modalities and for each observer. For statistical analyses, data were imported to SPSS® (IBM Corp., New York, NY).

Interobserver reproducibility for all radiographic parameters separately (both morphological and pathological) for the two imaging modalities was estimated by two outcome variables: percentage of observer accordance and by κ statistics. Moreover, κ statistics was used to assess intraobserver reproducibility. κ values were interpreted as moderate to poor reproducibility if the value was <0.40, fair to good reproducibility if the value was between 0.40 and 0.75, and as excellent if the value was above 0.75.¹⁵ Furthermore, percentage agreement was used for comparison of the two imaging modalities.

For the comparison between pathological findings (marginal bone loss and resorption of the second molar and increased follicular space) in PAN and CBCT, frequencies for each pathology were calculated for each observer with both modalities. The frequency of resorption in the second molar was based on dichotomization of the data into: “no resorption” and “any resorption” (superficial resorption, <half way through the dentin, ≥half way through the dentin, and involving the pulp). Moreover, severity of resorption, using the full categorical scale, was calculated for each observer with both imaging modalities.

To assess indicators in panoramic images for marginal bone loss and resorption of the second molar observed in CBCT, only patients referred to CBCT because of suspicion of one of these pathologies were included in the further analyses ($n = 98$). Initial logistic regression analyses were performed to assess whether findings of marginal bone loss and resorption (based on the dichotomized data) in panoramic imaging were valid as indicators for marginal bone loss and resorption observed in CBCT. Only parameters with a statistically significant impact in the initial logistic regression analyses ($p < 0.05$) were entered in the final multivariate logistic regression analyses with resorption (yes/no) and marginal bone loss (yes/no) as the outcome variable, respectively.

Results

Observer reproducibility of PAN and CBCT

The percentage of observer accordance among observer pairs varied between 48.3 and 97.5% for CBCT and between 34.2 and 98.3% for PAN (Table 2). There was a large variation in κ values (0.14–0.76 for CBCT and 0.08 to 0.93 for PAN). For CBCT, only two pairs of observers managed to obtain κ values above 0.75 corresponding to excellent reproducibility (Table 2), whereas the percentage of observer accordance was above 90% for several parameters, which must also be considered high.

Comparison of the interobserver accordance showed that “angulation” and “increased follicular space” had a slightly higher percentage accordance for PAN than for CBCT. The percentage accordance regarding “angulation” was on average 76.7% for CBCT and 81.8% for PAN among observer pairs, and a κ value corresponding to good to excellent reproducibility was obtained. For “increased follicular space” seen in PAN, an average percentage of accordance of 96.4% was reached, and an average κ value of 0.56 was found. For CBCT, the average percentage of observer accordance was a bit lower (93.1%), and the average κ value was only 0.35 corresponding to moderate to poor reproducibility.

The remaining parameters; “number of roots” and “resorption” showed in general a higher reproducibility for CBCT than for PAN regarding percentage of observer accordance and κ values (Table 2). For “marginal bone loss,” the average κ values for both PAN and CBCT were 0.65 corresponding to fair to good reproducibility. “Bony impaction” showed a high percentage of observer accordance for both imaging modalities with an average of 93.3% for CBCT and 88.7% for PAN, though the κ values showed a wider range for CBCT than for PAN (Table 2). On the other hand, “resorption” was the parameter with the lowest reproducibility for PAN, varying from 34.2 to 60.0% in percentage of observer accordance and no κ value above 0.40 (Table 2). In comparison, the values for CBCT were markedly higher, the percentage accordance ranged from 48.3 to 70.8% with κ values between 0.34 and 0.62,

Table 2 Interobserver reproducibility presented as percentage of observer accordance and κ values for each observer pair

Variable	Observer 1 vs Observer 2	Observer 1 vs Observer 3	Observer 1 vs Observer 4	Observer 2 vs Observer 3	Observer 2 vs Observer 4	Observer 3 vs Observer 4
Angulation						
PAN	81.7% (0.68)	77.5% (0.65)	86.7% (0.77)	76.7% (0.63)	86.7% (0.78)	81.7% (0.72)
CBCT	80.8% (0.66)	70.0% (0.55)	81.7% (0.70)	69.2% (0.52)	81.7% (0.68)	76.7% (0.64)
Number of roots						
PAN	61.7% (0.38)	46.7% (0.20)	56.7% (0.33)	67.5% (0.47)	65.8% (0.45)	66.7% (0.44)
CBCT	85.0% (0.76)	76.7% (0.63)	76.7% (0.65)	80.8% (0.69)	81.7% (0.72)	81.7% (0.72)
Bony impaction						
PAN	78.3% (0.50)	83.3% (0.62)	82.5% (0.60)	95.0% (0.85)	95.8% (0.87)	97.5% (0.93)
CBCT	91.7% (0.34)	90.8% (0.13)	90.8% (0.37)	97.5% (0.56)	94.2% (0.43)	95.0% (0.38)
Size of follicular space						
PAN	95.8% (0.60)	97.5% (0.56)	98.3% (0.74)	95.0% (0.48)	94.2% (0.44)	97.5% (0.56)
CBCT	90.8% (0.33)	92.5% (0.50)	91.7% (0.46)	95.0% (0.23)	95.9% (0.43)	92.5% (0.14)
Marginal bone level						
PAN	89.2% (0.71)	84.2% (0.60)	86.7% (0.63)	85.0% (0.62)	87.5% (0.65)	87.5% (0.67)
CBCT	88.3% (0.60)	85.8% (0.50)	93.3% (0.74)	89.2% (0.67)	90.0% (0.67)	90.8% (0.69)
Resorption						
PAN	53.3% (0.34)	34.2% (0.08)	51.7% (0.33)	46.7% (0.18)	60.0% (0.40)	46.7% (0.22)
CBCT	70.8% (0.62)	56.7% (0.44)	48.3% (0.34)	58.3% (0.47)	58.3% (0.46)	55.8% (0.44)

CBCT, cone beam CT; PAN, panoramic images.

which means that the observers agreed more in their findings in CBCT than in PAN (Table 2).

In general, the intraobserver reproducibility was higher than the interobserver reproducibility for all observers. Assessing PAN, the ranges of κ values were: 0.63–1.0 for Observer 1; 0.75–1.0 for Observer 2; 0.15–1 for Observer 3 and 0.62–1.0 for Observer 4. Assessing CBCT volumes, the ranges of κ values were: 0.35–0.71 for Observer 1; 0.75–1.0 for Observer 2; 0.64–1 for Observer 3 and 0.38–1 for Observer 4. For some variables the intraobserver reproducibility was higher for PAN than CBCT and *vice versa*. For “marginal bone loss,” the intraobserver κ values ranged from 0.77 to 1.0 (95–100% agreement) and 0.64–1.0 (90–100% agreement) for PAN and CBCT, respectively. For “resorption,” the intraobserver κ values ranged from 0.69 to 1.0 (80–100% agreement) and 0.38–1.0 (75–100% agreement) for PAN and CBCT, respectively.

Comparison between pathological findings in PAN and CBCT

The frequency of marginal bone loss at the distal surface of the maxillary second molar was almost the same in PAN and CBCT, though somewhat higher on average for CBCT (84.9%) than for PAN (81.6%). Agreement between observations made by the same observer in PAN and CBCT for this parameter was relatively high, in the range of 80.6–87.8% (Table 3). Three of the four observers observed marginal bone loss more often in CBCT than in PAN; however, it was the opposite for Observer 2. Results from the logistic regression analyses showed that for two observers, a mesio-angulated third molar [odds ratio (OR) 16.6–33.8; $p < 0.012$;

confidence interval (CI) (1.8–373.9)] assessed in PAN significantly predicted that marginal bone loss was seen in the following CBCT. Thus, if a maxillary third molar was mesio-angulated in a PAN, there was a 17–34 times higher risk that marginal bone loss at the distal surface of the second molar was observed in the subsequent CBCT compared with other tooth angulations. None of the other morphological parameters were related to bone loss. Further, for two observers, marginal bone loss assessed in PAN significantly predicted that marginal bone loss was also seen in the following CBCT (OR 8.8–52.8; $p < 0.02$; CI 1.4–631.8), *i.e.* there was a 9–53 times the risk that marginal bone loss was also observed in CBCT, when seen in PAN.

Table 3 Observation of marginal bone loss (yes/no) at the distal surface of the maxillary second molar by the four observers in PAN and CBCT of the same cases

		CBCT							
		Obs 1		Obs 2		Obs 3		Obs 4	
PAN		Yes	No	Yes	No	Yes	No	Yes	No
Obs 1	Yes	77	4						
	No	8	9						
Obs 2	Yes			73	10				
	No			8	7				
Obs 3	Yes					68	5		
	No					14	11		
Obs 4	Yes							78	5
	No							7	8

CBCT, cone beam CT; PAN, panoramic images.

Figure 1 The distribution of severity of resorption in the maxillary second molar assessed in PAN and CBCT (0, no resorption; 1, superficial resorption; 2, resorption < half way through the dentin; 3, resorption ≥ half way through the dentin; 4, resorption involving the pulp) among the four observers. CBCT, cone beam CT; PAN, panoramic images.

The distribution of severity of resorption in the distal surface of the maxillary second molar can be seen in Figure 1. Evidently, more severe resorption was observed in CBCT than in the PAN for all observers, and resorption into the pulp was seen in 18–24% of cases. The average frequency of resorption (no matter severity) was 81% for both PAN and CBCT, but agreement was low, as can be calculated from Figure 1 and Table 4. In Figures 2 and 3, examples of two cases are shown with the two methods including the four observers' scores of resorption in these specific cases. Results from the logistic regression analyses revealed

that resorption seen in a PAN was not a significant indicator that resorption in the second molar was also observed in CBCT ($p > 0.05$) for any observer, and no specific tooth angulation or root number predicted resorption.

The frequency of an increased follicular space, interpreted as a cyst, was on average 2.8% in PAN and 4.6% in CBCT. Agreement between the methods varied between 63.3 and 70.4% among observers. This parameter was not further evaluated due to the small number of cases.

Table 4 Observation of resorption (yes/no) in the distal surface of the maxillary second molar by the four observers in PAN and CBCT of the same cases

	CBCT							
	Obs 1		Obs 2		Obs 3		Obs 4	
PAN	Yes	No	Yes	No	Yes	No	Yes	No
Obs 1	Yes	75	8					
	No	11	4					
Obs 2	Yes		69	11				
	No		10	8				
Obs 3	Yes				74	13		
	No				9	2		
Obs 4	Yes						53	15
	No						16	14

CBCT, cone beam CT; PAN, panoramic images.

Discussion

Guidelines stating when to perform a CBCT in addition to a PAN of maxillary third molars are non-existing. In the absence of guidelines, the use of CBCT so far is based solely on “good clinical practice”.^{3,16} When proposing new guidelines, it is important to assure that patients benefit from the examination, *i.e.* it likely changes the intervention and improves patient outcome, since the examination is associated with extra radiation dose.⁴ On the other hand, it may be that the development of new CBCT units offering ultra-low dose imaging protocols will change the awareness (if the image quality is equal) if the dose will be comparable to that of a PAN, but the CBCT should still be considered a supplement to a two-dimensional method since it is related to much higher costs.⁴ The National Institute for Health and Care Excellence states that intervention is indicated when irreversible pathology related to the third molar exists.² Furthermore, the institute does not recommend prophylactic removal of third molars. Both an increased follicular space (suggesting a cyst),

marginal bone loss, and resorption in the distal surface of the maxillary second molar seen in radiographs are considered irreversible pathology, which indicates intervention. The focus of our study was the association between observations made in PAN and CBCT among observers to assess whether a CBCT is indicated when a PAN is already available.

Observer reproducibility of PAN and CBCT

Comparing all observers, no observer pair revealed persistently lower or higher interobserver reproducibility than others, and no substantial differences were seen between the pre-graduate student and the three oral radiologists. In a previous study, it was found that experienced radiologists were more reproducible compared to pre-graduate students when assessing mandibular third molars in CBCT.¹⁷ We have chosen to express both percentage accordance and κ values for reproducibility since we believe that κ statistics cannot stand alone. For some parameters there was a very high percentage of observer accordance while the κ value was low. The low κ value occurs because of the distribution of the findings between the two observers in question. As an example, the percentage observer accordance for “bony impaction” was 90.8% between Observer 1 and 3 and the κ value 0.13. Thus, the two observers agreed in most of the recordings expressed by the high percentage value. The reason for the low κ value is that despite the fact that the majority of cases was observed as “no bony impaction” by both observers, the observers did not agree on the few cases where the third molar was possibly impacted in bone.

In the present study, the percentage accordance among observers for marginal bone loss was on average 87% for PAN and 90% for CBCT. The percentage accordance is rather high, even though we did not measure the exact marginal bone level, since it was merely a subjective assessment of bone level in both imaging modalities. If the bone level had actually been measured, it may be speculated that both percentage accordance and κ values for both imaging modalities would be even more accurate and precise among observers.¹⁸ Intraobserver agreement was somewhat higher than interobserver agreement. No previous study has assessed observer reproducibility of marginal bone loss at the second maxillary molar, but our values were higher compared to those in another study evaluating mandibular third molars, which found percentage of observer accordance to be 69% on average for PAN and 72% in CBCT among four observers.¹⁹

Resorption was the parameter that revealed the lowest interobserver reproducibility for both imaging modalities, represented by an average of 48% and 0.26 for PAN and 58% and 0.46 for CBCT. These values indicate a fair to good reproducibility for CBCT compared with the values for PAN, which only corresponds to poor to moderate reproducibility. Again, intraobserver agreement was higher than interobserver agreement,

indicating that each observer had an individual, but rather consistent, interpretation of resorption. It may be speculated that resorption can be difficult to see in both imaging modalities. When PAN is assessed, the two-dimensional view causes struggle because of overprojection of neighboring teeth or anatomical structures, such as the maxillary sinus and the zygomatic bone. Studies on interobserver reproducibility regarding the maxillary third molar seen in PAN and CBCT are non-existing since the studies either did not mention the number of observers or reported only results made in consensus, and interobserver reproducibility was not calculated.^{8–12} On the other hand, studies on assessment of pathology related to the mandibular third molar are available in the literature.^{19–23} In a previous study assessing resorption in PAN and CBCT of mandibular third molars, the average percentage of observer accordance was 83% for PAN and 72% in CBCT among four observers.¹⁹ Interobserver reproducibility for both PAN and CBCT seems therefore to be lower for maxillary third molars than for mandibular third molars. Resorption is probably more easily seen in the mandibular than in the maxillary second molar in PAN, because overprojection of anatomical structures and neighboring teeth is less pronounced in the lower jaw. Moreover, it can be speculated that the zygomatic bone and the maxillary sinus, which is filled with air, produces artefacts that may affect the ability to visualize root resorption in the maxilla.

Comparison between pathological findings in PAN and CBCT

Our study can be considered a Level-3 study in F&T's model of evidence of a diagnostic imaging method since it investigated whether the diagnosis was changed when CBCT was compared to a PAN, and the treatment was performed based on findings in CBCT.

The average frequency of marginal bone loss was slightly higher in CBCT than in PAN. Several of the same cases were scored with marginal bone loss in both the PAN and CBCT by the four observers, especially by observers 2 and 4. Therefore, it could fairly well be predicted that marginal bone loss at the distal surface of the second molar was observed in CBCT, when it was seen in the PAN. This fact may be reflected in the surgeons' referrals for CBCT since only two patients were referred for assessment of marginal bone loss. There was also an increased risk of observing marginal bone loss in CBCT if the third molar was mesio-angulated. Similar findings have been shown for mandibular third molars, but in these cases also horizontally positioned third molars in the PAN influenced marginal bone loss as observed in the CBCT.¹⁹ A possible explanation of the fact that we were unable to show an association between marginal bone loss and horizontal positioning of the maxillary third molar, may be due to the present sample having very few horizontally positioned third molars.

As mentioned above, the average frequency for resorption was the same for both imaging modalities

(81%), but it varied between the methods, which cases were scored with resorption. Only one previous study has compared pathological findings in PAN with findings in CBCT for maxillary third molars.¹² The study did not examine marginal bone loss, but external root resorption in the distal surface of both mandibular and maxillary second molars was assessed by two observers. Findings of resorption in the mandible and the maxilla were not reported separately though, and therefore the results of the study cannot be compared with our results. None of the parameters seen in PAN were able to predict that resorption would be seen in CBCT. This seems also to reflect the surgeons' referral behavior since 82% of the referrals to CBCT of a maxillary third molar were on suspicion for resorption, *i.e.* the surgeons acknowledge this difficult task. A recent study on mandibular third molars found a significant association between the position of the third molar and presence of resorption in the distal surface of the second molar.¹⁹ Both a mesio-angulated and horizontal position in the PAN were associated with subsequent findings of resorption in CBCT.¹⁹ The low occurrence of horizontally positioned maxillary third molars in our study might be the reason why we were unable to show an association between resorption and horizontal positioning of the maxillary third molar. Moreover, resorption in the second molar was also frequently observed in cases with a vertical position of the third molar in addition with a bucco-oral inclination of the tooth, but this latter inclination was not assessed herein.

In our material, we observed an increased follicular space around the crown of the third molar interpreted as a cyst only in very few cases and due to the low number, we were not able to test for significant correlations between the methods. On the other hand, the observers on average observed more cysts the CBCTs than in the PAN. This was not a surprising result since this can be difficult to observe in a PAN because of overprojection of the teeth and anatomical structures, and when a dark

band of air is present between the patient's tongue and palate.

It may be speculated that the severity of resorption observed in the second molar may affect the treatment decision. The severity of resorption in the second molar could influence whether the surgeon will eventually remove the second molar instead of the third molar (or both teeth). If a CBCT is available, the clinician will probably rely more on the findings in the CBCT. This is supported by the fact that our study showed a higher interobserver reproducibility for CBCT compared to PAN regarding resorption for both percentage accordance (between 34–60% for PAN and 48–71% for CBCT) and κ values (ranging 0.08–0.40 for PAN and 0.34–0.62 for CBCT). Treatment decision was not evaluated in the present study, and studies on the impact of CBCT on the treatment of maxillary third molars have so far not been conducted. This should be next-step study in setting up guidelines for the use of CBCT for impacted maxillary third molars, reaching level four and further in the F&T hierarchy.

Conclusively, the observers found almost the same frequency of pathology (marginal bone loss and resorption in the second molar and increased follicular space around the crown of the third molar) in PAN and CBCT images, however resorption was not seen in the same cases with the two methods. PAN may to some extent predict that marginal bone loss at the distal surface of the second maxillary molar will also be observed in CBCT. On the other hand, PAN is not able to predict resorption in the distal surface of the maxillary second molar as observed in CBCT. CBCT is therefore indicated if knowledge of resorption in the second molar is important for the treatment decision. Furthermore, our results also indicate that determination of the severity of resorption is more reliable in CBCT than in PAN. In the decision on whether to remove the maxillary second molar instead of the third molar when severe resorption is seen, CBCT may be helpful to the clinician.

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