SHORT COMMUNICATION

Reproducibility of mandibular third molar assessment comparing two cone beam CT units in a matched pairs design

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The aim of this study was to evaluate the reproducibility of the third molar assessment, comparing five observers and two cone beam CT (CBCT) units. 28 patients, each with two impacted mandibular third molars, were included. Each patient was randomly examined with a Scanora® 3D (Soredex, Helsinki, Finland) CBCT unit in one mandibular third molar region and with a Cranex® 3D (Soredex) CBCT unit in the other region. Five observers with varying CBCT experience assessed all third molars and recorded the following variables: number and morphology of the roots, relation to the mandibular canal in two directions, shape of the canal and whether there was a direct contact between the roots of the molar and the mandibular canal. The radiographic assessments were compared pairwise among all observers for all variables. Wilcoxon's signed-rank test was used to test the differences in observer accordance percentages among the recorded variables in the images from the two units, and kappa statistics expressed interobserver reproducibility. The mean percentages for observer accordance ranged from 65.4 to 92.9 for Scanora 3D and 60.3 to 94.8 for Cranex 3D. There was no significant difference between the observer accordance in the two CBCT units ($p > 0.05$), except for assessing root flex in the mesiodistal direction, for which the observer accordance was higher for Scanora 3D ($p < 0.05$). Kappa values ranged from 0.1 to 1.0 for Scanora 3D and from 0.2 to 0.9 for Cranex 3D. For the variable "direct contact", the interobserver reproducibility was excellent for the two trained radiologists. The two units had almost similar interobserver reproducibility for mandibular third molar assessment. Observer variation existed, and experienced radiologists demonstrated the highest interobserver reproducibility for canal-related variables.

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Introduction

Cone beam CT (CBCT) has become a method for assessing mandibular third molars with an indication for removal and with a suspected intimate relationship to the mandibular canal.¹ Because this method provides a three-dimensional data set, it could be speculated that CBCT is more accurate than conventional two-dimensional radiographic methods in displaying third molar morphology and its related anatomical structures.

In several studies, CBCT has been used as the reference standard to determine the accuracy of conventional methods, e.g. panoramic imaging.²⁻⁶ However, it was concluded in a recent review that CBCT should not be used as a reference standard because, being a diagnostic method, this is apt to both false-positive and false-negative recordings.^{7,8}

To be acknowledged as a reference standard, first of all, a method needs to be reproducible,⁹ and several studies have evaluated the reproducibility of CBCT for assessment of mandibular third molars.^{2,5,6,10-12} In a few studies, the interobserver agreement between the two observers in terms of kappa values was interpreted

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as “excellent” for the assessment of direct contact between the third molar and the mandibular canal in CBCT images.^{2,6,10} This was also confirmed by two other studies, which, in addition, found an excellent interobserver agreement for assessing the buccolingual relation between these structures.^{5,11} The latter study also demonstrated an excellent intraobserver reproducibility for assessment of both variables. Furthermore, in another study, both direct contact and number of roots were found to have excellent intraobserver and interobserver agreement.¹² These previous studies only included two observers. These two observers were stated to be either trained radiologists or oral and maxillofacial surgeons. The reproducibility of other variables related to the examination of the mandibular third molar has been sparsely evaluated.

The aim of the present study was to assess the interobserver reproducibility of trained and less-well-trained observers for assessing mandibular third molars, comparing two CBCT units in a matched pairs design.

Materials and methods

28 patients (12 males and 16 females; mean age, 28.5 years; range, 18.7–53.8 years) were referred by their general dental practitioner for a CBCT examination and for assessment of both their impacted mandibular third molars ($n = 56$). Two CBCT units were used: Scanora[®] 3D (Soredex, Helsinki, Finland) and Cranex[®] 3D (Soredex). In the Scanora 3D unit (panel size 124×124 mm), the patients were examined with a 6×6 cm field of view (FOV), and in the Cranex 3D unit (panel size 100×68 mm), the patients were examined with a 6×4 cm FOV. The FOV was centred at the mandibular third molar region. Each patient was examined using both units (Figure 1), one in each molar side, in a randomized order. The CBCT volumetric data sets (one for each third molar region) were reconstructed to display two-dimensional image sections (both units with a voxel size of 0.133, which also was the thickness of the image sections) in three planes: axial, sagittal and coronal. The data sets were viewed using OnDemand[®] software v. 1.0.8.0408 (Cybermed Inc., Seoul, Republic of Korea). All images were assessed in a room with window covers and with the light turned off on one of two monitors with inplane switching technology: Dell[™] UltraSharp 2007FP 20.1 inch flat panel liquid-crystal display monitor (Dell Inc., Austin, Texas; resolution, 1600×1200 pixels; pixel pitch, 0.255 mm) or HP[®] L2245wg 22 inch widescreen liquid-crystal display monitor (Hewlett-Packard, Palo Alto, CA; model: FL472A8) (resolution, 1600×1050 pixels; pixel pitch, 0.282 mm).

Five observers [two trained radiologists with more than 5 years' experience with CBCT for mandibular third molar assessment (Observers 2 and 3), one less-well-trained observer with 1 year's experience with CBCT for mandibular third molar assessment (Observer 4) and two dental students with 1 month of training with

CBCT for mandibular third molar assessment (Observers 1 and 5)] individually assessed the data sets and recorded the following variables: (1) number of roots (1/2/more than 2), (2) flex of the roots (straight/mesial/distal/buccal/lingual), (3) relation to the mandibular canal in the craniocaudal direction (superior/between the upper and the lower borders of the canal/inferior) (Figure 2), (4) relation to the mandibular canal in the buccolingual direction (buccal/lingual/same level) (Figure 3), (5) direct contact between the tooth and the mandibular canal; *i.e.* no bony separation between the tooth/roots and the mandibular canal (yes/no) (Figure 4) and (6) change in shape of the mandibular canal; *i.e.* change in direction course (yes/no) and/or lumen narrowing (yes/no) (Figure 5). The observers were blinded to the unit used, except one of the radiologists (Observer 3), who was able to recognize the images from the two units.

All radiographic recordings were compared among all observers for all variables. The frequencies of accordance between the recordings were calculated among all observers in a pairwise design, for all variables and for images from the two units, respectively. Root morphology was recoded for the mesial and distal roots separately: (1) flex in the mesiodistal direction and (2) flex in the buccolingual direction.

Reproducibility was estimated by two outcome variables: percentage of observer accordance and interobserver agreement expressed by kappa statistics. Wilcoxon's signed-rank test was used to test differences between observer accordance for images from the two units for all variables. Kappa values greater than 0.75 were defined as excellent agreement, those between 0.40 and 0.75 as “fair-to-good” agreement and those less than 0.40 as “moderate-to-poor” agreement.¹³ Data were analysed using SPSS[®] v. 13.0 (SPSS Inc., Chicago, IL), and a 5% level of significance was applied.

Results

Table 1 lists the percentages of accordance between the observers, pairwise for all variables assessed in the data sets from the two units. The frequencies of accordance among the observers ranged from 39% to 100% for both units. There was no significant difference between observer accordance between the two units ($p > 0.05$) except during assessment of root flex in the mesiodistal direction on the mesial root, for which the observer accordance was higher for Scanora 3D than for Cranex 3D ($p < 0.05$). Overall kappa values ranged from 0.1 to 1.0 for Scanora 3D and from 0.2 to 0.9 for Cranex 3D (Table 2). In several cases, kappa values could not be calculated, because all categories of a variable were not used by one of the observers in a pair. As shown in Table 2, this is frequently present when Observer 4 was included in a pair.

The mean observer accordance for “number of roots” was 75.6%, and the mean kappa value was 0.42. The

Figure 1 Axial, coronal and sagittal sections of two mandibular third molars in the same patient. (a) Right molar examined with Scanora[®] 3D (Soredex, Helsinki, Finland) and (b) left molar examined with Cranex[®] 3D (Soredex)

mean accordance and kappa values for the two radiologists were 87.5% and 0.56, respectively. From [Tables 1](#) and [2](#), it can be seen that the highest mean observer accordance and mean kappa value were recorded for the variable “flex of the mesial root in the buccolingual direction” and the second highest values for the same recording of the distal root. Root flex in the buccolingual direction showed higher interobserver reproducibility than root flex in the mesiodistal direction. For the two trained radiologists, mean observer accordance and kappa values for recordings of buccolingual flex were 90.2% (range, 82.1–96.4%) and 0.83 (range, 0.78–0.87), respectively, and 76.8% (range, 71.4–89.4 %) and 0.49 (range, 0.35–0.77), respectively, for flex in the mesiodistal direction.

For the canal-related variables, the mean observer accordance and mean kappa values were in general lower than those for the tooth/root-related variables. Observer accordance was almost the same for variables 3, 4 and 6 ([Table 1](#)). The mean kappa values, however, differed, and it can be seen from [Table 2](#) that the reproducibility of the relation between the third molar and the mandibular canal in the buccolingual direction

(kappa = 0.53), in particular, was higher than that in the craniocaudal direction (kappa = 0.38) and for the shape of the canal (kappa = 0.43). The highest frequency of observer accordance for canal-related variables was seen for direct contact to the mandibular canal (79.3%), which also showed the highest mean kappa value (0.57). Particularly, between the two radiologists, the reproducibility was high (96% and 93%, respectively), and the kappa values indicated excellent agreement (Scanora 3D = 0.92 and Cranex 3D = 0.86).

Discussion

For the tooth/root-related variables, observer reproducibility for assessment of mandibular third molars in CBCT data sets has been sparsely evaluated. Only one other study had examined the reproducibility of number of roots between two radiologists.¹² In that study, a very high interobserver agreement was found (kappa = 0.95).¹² This result is higher than that of the present study, although a higher interobserver reproducibility was found between the two trained

Figure 2 Craniocaudal relationship between the roots and the mandibular canal assessed in the sagittal plane: (a) superior, (b) between the upper and the lower border of the canal and (c) inferior

Figure 3 Buccolingual relationship between the roots and the mandibular canal: (a) buccal, (b) lingual and (c) same level. L, lingual; B, buccal

radiologists than among the remaining observers. However, very high interobserver reproducibility for assessing root flex in both directions was found for all observer pairs. Thus, from these results, training does not seem to influence the interpretation of flex of the roots in contrast to assessing number of roots.

Several studies have examined observer reproducibility for the assessment of mandibular third molars in CBCT data sets for canal-related variables.^{2,5,6,10–12} The mean kappa value for assessing the relation to the mandibular canal in the buccolingual direction for the two trained radiologists was 0.65, which was “good”, but lower than the kappa values reported in two previous studies on reproducibility of CBCT images.^{5,11} The validity of this specific variable may be important because this knowledge is vital to the surgeon so that he or she knows what to expect when bone removal is needed in connection with removal of the tooth. Another canal-related variable in the present study was “change in shape of the canal”. In a recent study, it was found that lumen narrowing influenced a surgeon’s treatment decision, because in many cases, the treatment plan changed from surgical removal to coronectomy when lumen narrowing was observed in CBCT image sections.¹⁴ In the present study, the reproducibility was rather high for this variable.

In the present study, “direct contact” had the highest reproducibility for the canal-related variables, especially between the two trained radiologists, where an excellent

agreement was found. This result conforms with results from other previous studies that have reported kappa values of 0.75–1.0 for this variable for trained observers.^{2,5,6,10–12} Of the variables tested in our study, this variable has been shown to be of greatest importance to surgeons, given that a recent study has reported that direct contact had the major influence on a surgeon’s treatment decision for mandibular third molar surgery: removal of the tooth *vs* coronectomy.¹⁴ Consequently, it is of utmost importance that a surgeon can rely on the recordings and reports performed by a radiologist.

For all canal-related variables, the two trained radiologists obtained high percentages of observer accordance and kappa values. If performed by trained observers, it may be suggested that this observation could raise CBCT to the status of a “reference standard” or validation for an intimate relationship between the tooth/roots and the mandibular canal when studies are performed with the aim to compare conventional radiographic methods for this diagnostic goal. Hitherto, radiographic methods have been referenced against three intra- and post-operative signs, serving as a reference standard for a direct relation to the canal in the literature; namely, that the nerve is visible during or after removal of the tooth, that grooves formed by the nerve exist in the root complex of the tooth and/or that the patient reports post-operative changes in sensory feeling in the innervation area of the inferior alveolar nerve.¹⁵ No study has evaluated the reproducibility among surgeons of this clinical “reference standard”, and it can be speculated whether it would be reasonable in the clinical situation to conduct such a study because it would imply that more than one observer should look/search for the nerve after

Figure 4 Root contact to the mandibular canal: (a) direct contact and (b) no direct contact

Figure 5 Change in shape of the mandibular canal: (a) lumen narrowing and (b) change in direction course

Table 1 Total frequencies of accordance (%) between all observers, pairwise for all variables, for the two cone beam CT units

<i>Variable</i>	<i>Obs1/ Obs2</i>	<i>Obs1/ Obs3</i>	<i>Obs1/ Obs4</i>	<i>Obs1/ Obs5</i>	<i>Obs2/ Obs3</i>	<i>Obs2/ Obs4</i>	<i>Obs2/ Obs5</i>	<i>Obs3/ Obs4</i>	<i>Obs3/ Obs5</i>	<i>Obs4/ Obs5</i>	<i>Mean</i>
Number of roots											
Scanora	71.4	71.4	71.4	64.3	85.7	67.9	85.7	75.0	71.4	60.7	72.5
Cranex	60.7	67.9	78.9	71.4	89.3	75.0	89.3	82.1	92.9	78.6	78.6
Distal root flex—buccolingual											
Scanora	92.9	89.3	92.9	100	96.4	92.9	92.9	89.3	89.3	92.9	92.9
Cranex	96.4	85.7	96.4	96.4	82.1	92.9	92.9	89.3	82.1	92.9	90.7
Distal root flex—mesiodistal											
Scanora	71.4	67.9	82.1	78.6	75.0	82.1	57.1	78.6	67.9	75.0	73.6
Cranex	67.9	89.3	85.7	71.4	71.4	67.9	67.9	82.1	75.0	64.3	74.3
Mesial root flex—buccolingual											
Scanora	85.7	89.3	96.4	96.4	96.4	89.3	89.3	92.9	92.9	100	92.9
Cranex	89.3	96.4	96.4	100	85.7	92.9	89.3	92.9	96.4	96.4	93.6
Mesial root flex—mesiodistal											
Scanora	89.3	78.6	71.4	92.9	89.4	82.1	89.3	78.6	78.6	71.4	82.2
Cranex	67.9	67.9	60.7	75.0	71.4	71.4	71.4	78.6	71.4	64.3	70
Relation to the canal—craniocaudal											
Scanora	82.1	57.1	57.1	78.6	75.0	60.7	75.0	78.6	57.1	57.1	67.8
Cranex	78.6	64.3	64.3	67.9	71.4	71.4	71.4	64.3	75.0	67.9	69.7
Relation to the canal—buccolingual											
Scanora	71.4	64.3	39.3	75.0	67.9	64.3	82.1	57.1	67.9	64.3	65.4
Cranex	57.1	46.4	39.3	57.1	82.1	64.3	67.9	57.1	71.4	60.7	60.3
Direct contact											
Scanora	78.6	82.1	67.9	78.6	96.4	82.1	85.7	78.6	89.3	75.0	81.4
Cranex	82.1	82.1	60.7	71.4	92.9	64.3	82.1	71.4	82.1	82.1	77.1
Shape of the canal											
Scanora	67.9	75.0	67.9	71.4	78.6	78.6	64.3	78.6	64.3	64.3	71.1
Cranex	89.3	78.6	50.0	50.0	85.7	60.7	60.7	53.6	53.6	60.7	64.3

Cranex, Cranex® 3D (Soredex, Helsinki, Finland); obs, observer; Scanora, Scanora® 3D (Soredex, Helsinki, Finland).

Table 2 Pairwise kappa values for interobserver reproducibility for all variables, for the two cone beam CT units

<i>Variable</i>	<i>Obs1/ Obs2</i>	<i>Obs1/ Obs3</i>	<i>Obs1/ Obs4</i>	<i>Obs1/ Obs5</i>	<i>Obs2/ Obs3</i>	<i>Obs2/ Obs4</i>	<i>Obs2/ Obs5</i>	<i>Obs3/ Obs4</i>	<i>Obs3/ Obs5</i>	<i>Obs4/ Obs5</i>	<i>Mean</i>
Number of roots											
Scanora	0.45	0.37	0.42	0.36	0.67	0.37	0.72	0.40	0.40	0.29	0.45
Cranex	–	–	0.47	0.25	0.51	–	–	–	–	0.18	0.35
Distal root flex—buccolingual											
Scanora	0.63	0.52	0.46	1.00	0.87	0.63	0.63	0.52	0.52	0.46	0.62
Cranex	0.65	–	–	0.65	–	–	0.46	–	–	–	0.59
Distal root flex—mesiodistal											
Scanora	0.41	0.35	0.64	0.58	0.47	0.60	0.20	0.55	0.38	0.53	0.47
Cranex	0.25	0.73	0.62	0.41	0.35	0.25	0.34	0.55	0.55	0.30	0.44
Mesial root flex—buccolingual											
Scanora	–	–	–	–	0.78	–	–	–	–	–	0.78
Cranex	–	–	–	–	–	0.47	–	–	–	–	0.44
Mesial root flex—mesiodistal											
Scanora	0.75	0.52	0.45	0.81	0.77	0.65	0.75	0.58	0.52	0.45	0.63
Cranex	0.25	0.32	0.20	0.42	0.36	0.41	0.24	0.57	0.57	0.26	0.36
Relation to the canal—craniocaudal											
Scanora	0.58	0.23	0.16	0.40	0.55	0.23	0.36	0.61	0.19	0.11	0.34
Cranex	0.65	0.40	0.36	0.41	0.53	0.49	0.49	0.30	0.30	0.18	0.40
Relation to the canal—buccolingual											
Scanora	0.58	0.50	–	0.63	0.55	–	0.74	–	0.55	–	0.60
Cranex	0.37	0.24	–	0.38	0.75	–	0.54	–	–	–	0.46
Direct contact											
Scanora	0.57	0.64	0.36	0.57	0.92	0.56	0.69	0.50	0.77	0.39	0.60
Cranex	0.64	0.64	0.29	0.45	0.86	0.30	0.65	0.44	0.44	0.62	0.53
Shape of the canal											
Scanora	0.34	0.48	0.39	–	0.56	0.59	–	0.59	–	–	0.49
Cranex	–	–	–	0.21	–	0.30	–	–	–	–	0.26

Cranex, Cranex® 3D (Soredex, Helsinki, Finland); obs, observer; Scanora, Scanora® 3D (Soredex, Helsinki, Finland).

removal of the tooth. There are, in addition, many pitfalls in using this clinical reference standard, which have been described in detail in a recent report.¹⁵

For a method to be accepted as a “reference standard”, however, three criteria must be fulfilled:⁹ (1) it should be established using a method that in itself is precise, *i.e.* reproducible; (2) it should reflect the patho-anatomical appearance of the condition in question; and (3) it should be established independently of the diagnostic method under evaluation. Applying these criteria for CBCT in the assessment of mandibular third molars, it can be concluded that first, CBCT seems to be reproducible for some of the canal-related variables that are important for the surgeon to determine the treatment. Second, even though CBCT cannot be said to reflect the anatomical position of the inferior alveolar nerve, but rather merely to display the mandibular canal, it has been shown that when the nerve was visible during surgery, a direct contact between the tooth/roots and the mandibular canal was often demonstrated in the

CBCT sections, and the diagnostic accuracy for this variable was higher for CBCT than for other radiographic methods.^{8,10} CBCT may thus be used as a surrogate variable to demonstrate this relationship. Third, CBCT may fulfil the criterion that it is independent of other radiographic methods under evaluation because of its three-dimensional nature.

In conclusion, there was no difference in the percentage accordance and interobserver kappa agreement between the five observers between the Scanora 3D and the Cranex 3D units. Moreover, the level of training of an observer seems to influence the reproducibility, and for direct contact between the tooth and the mandibular canal, the reproducibility among trained observers was excellent with both units.

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