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Risk predictor signs on digital panoramic radiographs associated with mandibular canal compression on CBCT: A single-blinded retrospective comparison study

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ABSTRACT

Aim: Estimating the risk of inferior alveolar nerve (IAN) injury prior to mandibular third molar extraction is crucial. Whether this estimation should be done using panoramic radiographs or cone beam computed tomography (CBCT) is still controversial. The aim of this study was to compare between the compatibility of digital panoramic radiographs and cone beam computed tomography findings in predicting IAN injury. *Materials & Methods:* In a retrospective study design, a chart review was conducted to identify mandibular third molar extraction cases imaged with CBCT and panoramic radiographs. Two calibrated oral and maxillofacial radiologists reviewed the CBCT images for signs of canal compression and two oral and maxillofacial surgeons reviewed the panoramic images for signs that increase the likelihood of IAN injury. *Results:* Interruption of the mandibular canal cortex as identified on panoramic radiographs was most consistent with CBCT results and predicting IAN injury regardless of age and gender. Narrowing of the roots and bifid roots, however, were least consistent with CBCT findings. *Conclusion:* Only some of the imaging signs that predict IAN injury in digital panoramic radiographs were consistent with canal compression findings on CBCT images. Further correlation with surgical findings is necessary. *Clinical significance:* These results bring us closer to understanding the difference in diagnostic information provided by digital panoramic radiographs (2D) and CBCT examinations (3D) and the influence of this information on predicting IAN injury prior to mandibular third molar extraction.

Keywords: Chart review, CBCT, panoramic radiograph, mandibular, third molar

1. INTRODUCTION

The incidence of damage to the inferior alveolar nerve (IAN) after mandibular third molar extraction ranges from 1 to 22% (Eyrich et al., 2011). Once damage to the nerve occurs, repair is difficult because there is no consensus on the optimal method and timing of the repair (Kushnerev & Yates, 2015). Recognizing high-risk mandibular third molars before extraction is important because it allows surgeons to plan and perhaps modify the surgical approach to reduce the risk of iatrogenic nerve damage (Ali, Benton & Yates, 2018).

There are seven well-documented panoramic radiographic signs that predict contact between the third molar and the mandibular canal and injury to the IAN, which are called Rood's criteria (Nakamori et al., 2008; Rood & Shehab, 1990). Darkening of the root, narrowing of the root, interruption of the canal cortices, and canal diversion are significantly associated with an increased risk of IAN injury after the extraction of third molars (Park et al., 2010; Sedaghatfar, August & Dodson, 2005). Mandibular canal narrowing has also been documented as a significant signs that predicts post-extraction sensory impairment (Huang, Lui & Cheng, 2015). Currently, digital panoramic images are more commonly used than conventional panoramic radiographs and they are just as reliable as conventional panoramic radiographs to identify these signs (Bundy, Cavola & Dodson, 2009).

Pre-surgical evaluation of the third molars is routinely aided by the use of panoramic radiographic images. However, high-risk cases that present with signs that predict an intimate relationship between the impacted molar and the mandibular canal are usually referred for volumetric three-dimensional (3D) assessment using cone beam computed tomography (CBCT). CBCT accurately depicts the course of the canal, its topographic relationship to the third molar, and quantitatively assessing the compression of the canal, if present (Jadu, Alhazmi, Badr & Jan, 2017). In addition to assessing the integrity of the canal cortices, advanced imaging can measure the exact size of the cortical defect, if present. The size of the defect has been shown to be significantly related to intraoperative exposure of the canal when it is greater than or equal to 3mm wide (Susarla, Sidhu, Avery & Dodson, 2010). CBCT has decreased the incidence of IAN injury and, thus, improved the standard of care for patients with complicated third molar impactions (Korkmaz, Kayipmaz, Senel, Atasoy & Gumrukcu, 2017). Therefore, the aim of this study was to compare the performance of the two commonly used imaging modalities, digital panoramic radiographs and CBCT, in predicting the risk of IAN injury during mandibular third molar extraction.

2. MATERIALS AND METHODS

Ethics approval was obtained (REC 110-06-09). The methodology was based on the Jadu et al. study, where a cross sectional retrospective chart review was conducted. The chart review identified cases referred to a university based Oral and Maxillofacial Radiology service for imaging prior to mandibular third molar extraction. The inclusion criteria were modified to also include the presence of a recent (less than 5 years old) digital panoramic radiograph of acceptable quality (Jadu et al., 2017). This additional

inclusion criterion changed the total number of mandibular third molars that were available for the study from 100 to 79 molars in 48 patients.

The CBCT examinations were carried out using the same scanner and similar exposure parameters. Two calibrated OMFR first year residents (FD, DA) reviewed the CBCT images and recorded many data. Most importantly, they determined whether the canal was compressed or not and measured the dimension of the canal relative to the third molar.

The panoramic images were anonymized and coded, and then evaluated by two oral and maxillofacial surgeons (AJ and GD). The surgeons recorded the presence or absence of Rood's criteria, which are as follows: darkening of the roots, deflection of the roots, narrowing of the roots, dark and bifid root, diversion of the canal, narrowing of the canal, and loss of cortical outline on the mandibular canal. This was completed after a calibration exercise where the digital panoramic images of ten archive cases were reviewed to ensure standardization of the terminology and scoring criteria. The collected data were then compared to the data collected from the CBCT images, as detailed in Jadu et al. (Jadu et al., 2017). An example panoramic radiograph and select CBCT images of the same case are presented in Figures 1 and 2 to demonstrate the comparative process between the two imaging modalities.

Figure 1 Panoramic radiograph demonstrating an example of loss of mandibular canal cortical boundaries.

This is especially evident in the right side along the superior cortical surface of the canal in relation to the impacted mandibular third molar.

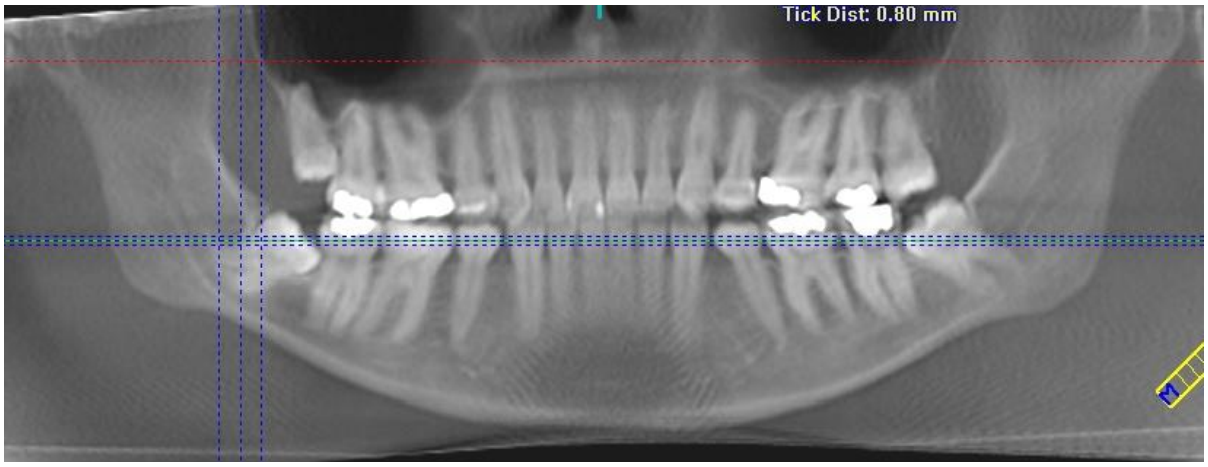

Figure 2 Reformatted panoramic CBCT image demonstrating loss of the cortical boundary of the mandibular canal in relation to the impacted right mandibular third molar. The reformatted cross sectional CBCT image displays proximity of the roots of tooth #48 to the mandibular canal (arrow).

This study was analyzed using IBM SPSS (SPSS Inc, Chicago IL, USA) version 23. Simple descriptive statistics were used to define the characteristics of the study variables using counts and percentages for the categorical and nominal variables while continuous variables are presented as the mean and standard deviation. Chi-square tests were used to establish a relationship between categorical variables. To learn more about the significant variables, we repeat the test by grouping them by demographics. Finally, the criteria to reject the null hypothesis was a conventional p-value <0.05.

3. RESULTS

Forty-eight patients were included in this study, with a mean age of 27 years and a nearly equal gender distribution (44% males and 55% females). There were 79 mandibular third molars analyzed and the distribution between right and left sides was also almost equal (51% tooth #38 and 48% tooth #48).

The agreement between the two Oral and Maxillofacial Surgeons (OMFS) observers ranged from fair to moderate, as shown in Table 1.

Table 1 Agreement between the two OMFS observers

Variables	AJ and GD
Darkening of the roots	0.436
Deflection of the roots	0.342
Narrowing of the roots	N/A[a]
Bifid root apex	0.473
Diversion of the canal	0.242
Narrowing of the canal	0.133
Loss of canal cortical outline	0.180

[a], No statistics were computed because the variable is a constant.

<0.001, Poor (Less than chance of agreement)

0.01–0.20, Slight (Slight agreement)

0.21–0.40, Fair (Fair agreement)

0.41–0.60, Moderate (Moderate agreement)

0.61–0.80, Substantial (Substantial agreement)

0.81–>0.99, Almost perfect (Almost perfect agreement)

There was a statistically significant difference in the following criteria: darkening of the roots, deflection of the roots, diversion of the canal, narrowing of the canal, and loss of the cortical outline of the canal. These results were consistent with the CBCT findings. These results are presented in Table 2. The statistically significant results are shown in Figure 3.

Table 2 Consistency rate between panoramic findings and CBCT results

			Causing Compression	In Contact	Separate	
Total		79	45(57.0%)	10(12.7%)	24(30.4%)	-
Darkening of the roots	0	53	23(43.4%)	9(17.0%)	21(39.6%)	0.002[a]
	1	26	22(84.6%)	1(3.8%)	3(11.5%)	
Deflection of the roots	0	70	36(51.4%)	10(14.3%)	24(34.3%)	0.022[a]
	1	9	9(100.0%)	0(0.0%)	0(0.0%)	
Narrowing of the roots	0	79	45(57.0%)	10(12.7%)	24(30.4%)	N/A[b]
	1	0	0(0.0%)	0(0.0%)	0(0.0%)	
Diversion of the canal	0	61	30(49.2%)	9(14.8%)	22(36.1%)	0.036[a]
	1	18	15(83.3%)	1(5.6%)	2(11.1%)	
Narrowing of the canal	0	61	29(47.5%)	9(14.8%)	23(37.7%)	0.007[a]
	1	18	16(88.9%)	1(5.6%)	1(5.6%)	
Loss of cortical outline	0	33	8(24.2%)	4(12.1%)	21(63.6%)	<0.001[a]
	1	46	37(80.4%)	6(13.0%)	3(6.5%)	
Bifid root apex	0	75	42(56.0%)	10(13.3%)	23(30.7%)	0.666
	1	4	3(75.0%)	0(0.0%)	1(25.0%)	

[a]-significant using Chi-Square Test <0.05 level.

[b]-no statistics are computed because the variable is constant.

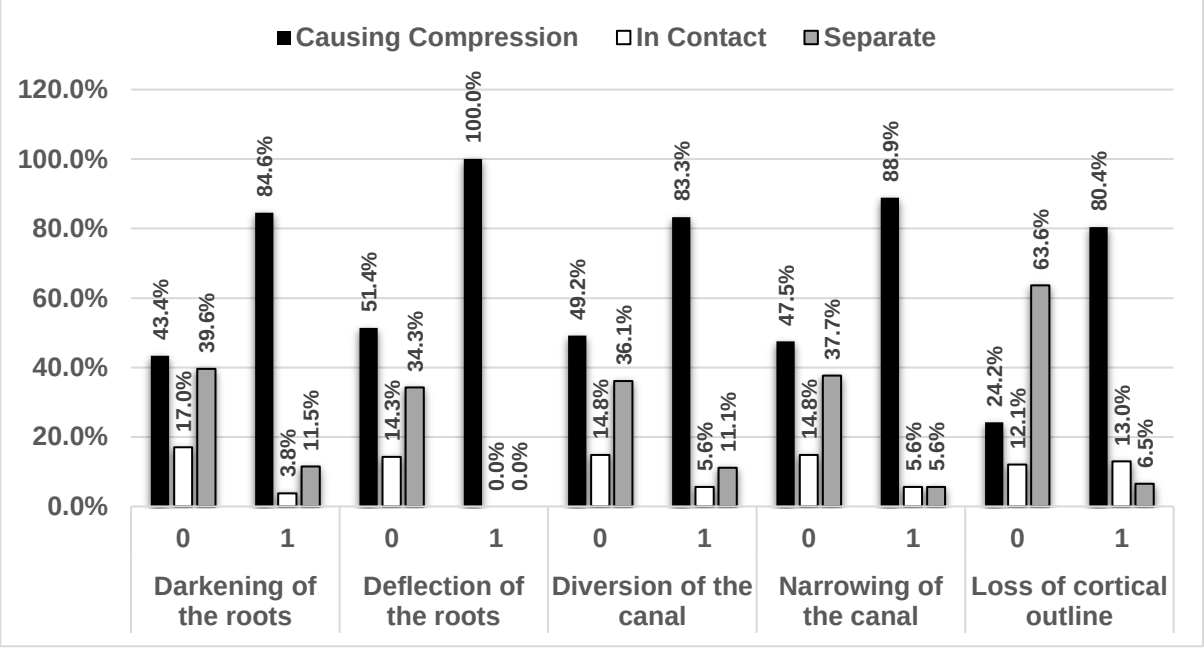

Figure 3 Bar graph demonstrating the statistically significant results in the consistency rate between panoramic findings and CBCT results

When age and gender were factored into the results, the significant findings changed and the two digital panoramic findings that correlated with the CBCT findings in the age group "younger than 21 years" were diversion of the canal and loss of the cortical outline of the canal (Table 3). The statistically significant results are demonstrated in Figure 2. For the group of patients "older than

21 years", the digital panoramic findings that correlated with the CBCT findings the most were darkening of the roots, narrowing of the canal, and loss of the cortical outline of the canal (Table 4). The statistically significant results are presented in Figure 4.

Table 3 Consistency rate between panoramic findings and CBCT results for patients 21 years of age and younger

Variables		Total	CBCT 3D relation			p-value
			Causing Compression	In Contact	Separate	
Total		17	9(52.9%)	4(23.5%)	4(23.5%)	-
Darkening of the roots	0	11	5(45.5%)	3(27.3%)	3(27.3%)	0.704
	1	6	4(66.7%)	1(16.7%)	1(16.7%)	
Deflection of the roots	0	13	5(38.5%)	4(30.8%)	4(30.8%)	0.098
	1	4	4(100.0%)	0(0.0%)	0(0.0%)	
Diversion of the canal	0	12	4(33.3%)	4(33.3%)	4(33.3%)	0.043[b]
	1	5	5(100.0%)	0(0.0%)	0(0.0%)	
Narrowing of the canal	0	15	8(53.3%)	3(20.0%)	4(26.7%)	0.546
	1	2	1(50.0%)	1(50.0%)	0(0.0%)	
Loss of cortical outline	0	7	3(42.9%)	0(0.0%)	4(57.1%)	0.013[b]
	1	10	6(60.0%)	4(40.0%)	0(0.0%)	

[b]-significant using Chi-Square Test <0.05 level.

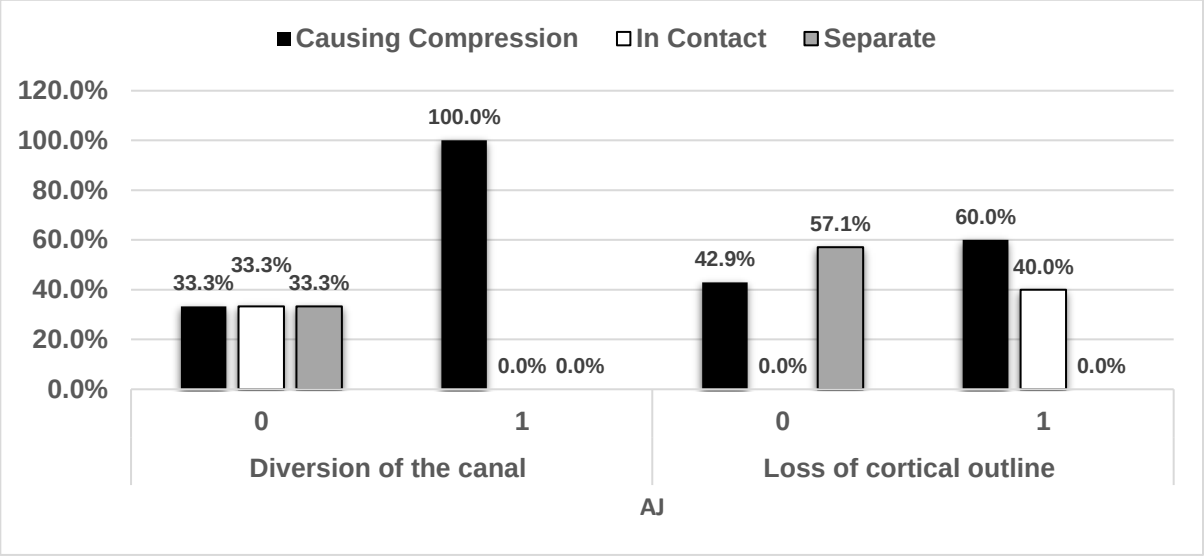

Figure 4 Bar graph demonstrating the statistically significant results in the consistency rate between panoramic findings and CBCT results for patients 21 years of age and younger.

Table 4 Consistency rate between panoramic findings and CBCT results for patients older than 21 years of age

Variables		Total	CBCT 3D relation			p-value
			Causing Compression	In Contact	Separate	
Total		61	35(57.4%)	6(9.8%)	20(32.8%)	-
Darkening of the roots	0	42	18(42.9%)	6(14.3%)	18(42.9%)	0.003[b]
	1	19	17(89.5%)	0(0.0%)	2(10.5%)	
Deflection of the roots	0	56	30(53.6%)	6(10.7%)	20(35.7%)	0.132
	1	5	5(100.0%)	0(0.0%)	0(0.0%)	
Diversion of the canal	0	48	25(52.1%)	5(10.4%)	18(37.5%)	0.259
	1	13	10(76.9%)	1(7.7%)	2(15.4%)	

Narrowing of the canal	0	45	20(44.4%)	6(13.3%)	19(42.2%)	0.003[b]
	1	16	15(93.8%)	0(0.0%)	1(6.3%)	
Loss of cortical outline	0	26	5(19.2%)	4(15.4%)	17(65.4%)	<0.001[b]
	1	35	30(85.7%)	2(5.7%)	3(8.6%)	

[b]-significant using Chi-Square Test <0.05 level.

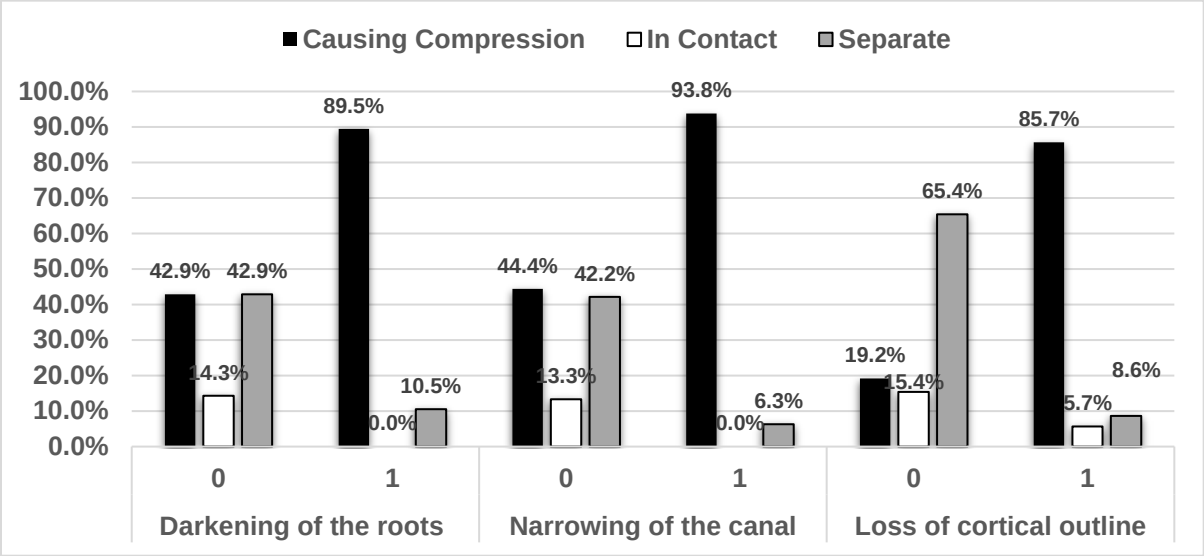

Figure 5 Bar graph demonstrating the statistically significant results in the consistency rate between panoramic findings and CBCT results for patients older than 21 years of age

For male patients, the digital panoramic findings that correlated most with the CBCT results were narrowing of the canal and loss of the cortical outline of the canal (Table 5). The statistically significant results are demonstrated in Figure 5. For female patients, the digital panoramic findings that correlated well with CBCT results were darkening of the roots, deflection of the roots, and loss of the cortical outline of the canal (Table 6). The statistically significant results are presented in Figure 6 & 7.

Table 5 Consistency rate between panoramic findings and CBCT results for males.

Variables		Total	CBCT 3D relation			p-value
			Causing Compression	In Contact	Separate	
Total		35	17(48.6%)	5(14.3%)	13(37.1%)	-
Darkening of the roots	0	25	10(40.0%)	4(16.0%)	11(44.0%)	0.271
	1	10	7(70.0%)	1(10.0%)	2(20.0%)	
Deflection of the roots	0	35	17(48.6%)	5(14.3%)	13(37.1%)	N/A[c]
	1	0	0(0.0%)	0(0.0%)	0(0.0%)	
Diversion of the canal	0	29	13(44.8%)	4(13.8%)	12(41.4%)	0.513
	1	6	4(66.7%)	1(16.7%)	1(16.7%)	
Narrowing of the canal	0	29	11(37.9%)	5(17.2%)	13(44.8%)	0.022[b]
	1	6	6(100.0%)	0(0.0%)	0(0.0%)	
Loss of cortical outline	0	13	1(7.7%)	1(7.7%)	11(84.6%)	<0.001[b]
	1	22	16(72.7%)	4(18.2%)	2(9.1%)	

[b]-significant using Chi-Square Test <0.05 level.

[c]-no statistics are computed because the variable is constant.

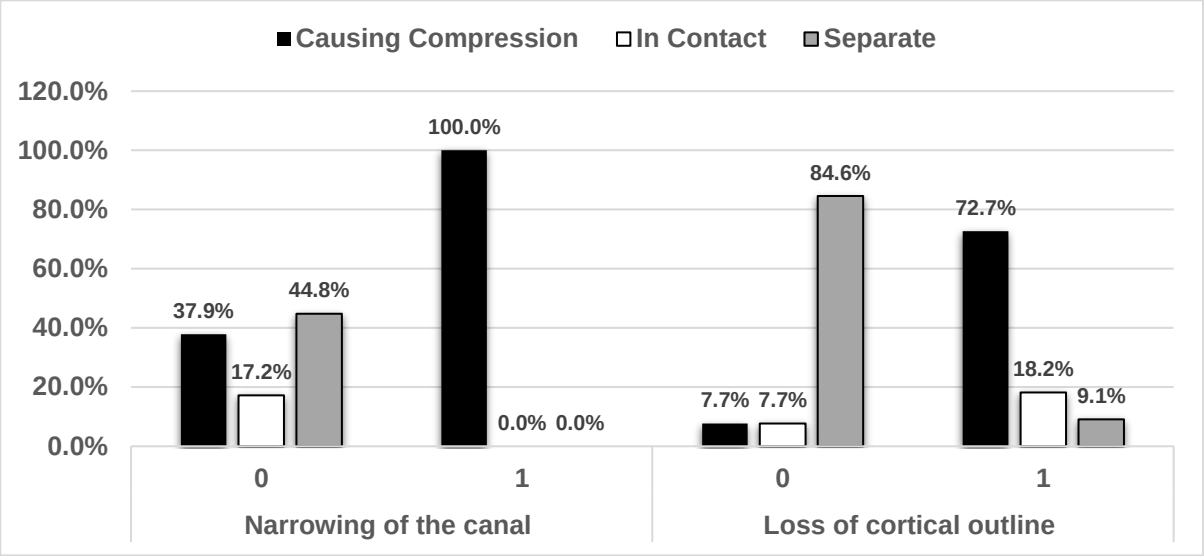

Figure 6 Bar graph demonstrating the statistically significant results in the consistency rate between panoramic findings and CBCT results for male patients

Table 6 Consistency rate between panoramic findings and CBCT results for females.

Variables		Total	CBCT 3D relation			p-value
			Causing Compression	In Contact	Separate	
Total		44	28(63.6%)	5(11.4%)	11(25.0%)	-
Darkening of the roots	0	28	13(46.4%)	5(17.9%)	10(35.7%)	0.007[b]
	1	16	15(93.8%)	0(0.0%)	1(6.3%)	
Deflection of the roots	0	35	19(54.3%)	5(14.3%)	11(31.4%)	0.039[b]
	1	9	9(100.0%)	0(0.0%)	0(0.0%)	
Diversion of the canal	0	32	17(53.1%)	5(15.6%)	10(31.3%)	0.057
	1	12	11(91.7%)	0(0.0%)	1(8.3%)	
Narrowing of the canal	0	32	18(56.3%)	4(12.5%)	10(31.3%)	0.226
	1	12	10(83.3%)	1(8.3%)	1(8.3%)	
Loss of cortical outline	0	20	7(35.0%)	3(15.0%)	10(50.0%)	0.001[b]
	1	24	21(87.5%)	2(8.3%)	1(4.2%)	

[b]-significant using Chi-Square Test <0.05 level.

4. DISCUSSION

Use of panoramic radiographs or CBCT for pre-surgical assessment of third molars remains controversial. Each imaging modality has its own set of advantages and limitations, which complicates the decision even further. Factors such as availability and accessibility are taken into consideration. In addition, radiation dose and the diagnostic information provided are always hot topics that fuel the debate. On the one hand, panoramic radiographs are two-dimensional and are distorted but are readily available. CBCT, on the other hand, is a 3D imaging technique that provides significantly more diagnostic information and possibly a greater dose of radiation. We posed the following question: How much information is diagnostically sufficient? The current study attempted to answer this question by comparing the ability of both imaging modalities to provide information that will accurately and consistently predict the risk of IAN injury prior to mandibular third molar extraction.

The digital panoramic radiographic finding that consistently correlated well with the CBCT results is loss of the cortical outline of the mandibular canal. This finding seems to be a consistent predictor of IAN injury regardless of the patient's age or gender (Susarla et al., 2010). Perhaps the consistency of this imaging finding is related to its ease of detection because it relies on the ability to differentiate between contrasting densities, which are the white of the cortical outline compared to the relative black of its absence. Several studies have demonstrated that the ability to perceive opacity is superior to the ability to perceive radiolucency (Perschbacher, Pharoah, Leake, Lam, & Lee, 2010; Stheeman, Mileman, van' t Hof, & van der Stelt, 1996). Narrowing of the

mandibular canal is another finding that correlates well between the two imaging modalities, especially for older patients and males. Jadu et al. reported in a previous study that compression of the canal usually occurs when the canal assumes a lingual position relative to the roots of the mandibular third molar (Jadu et al., 2017).

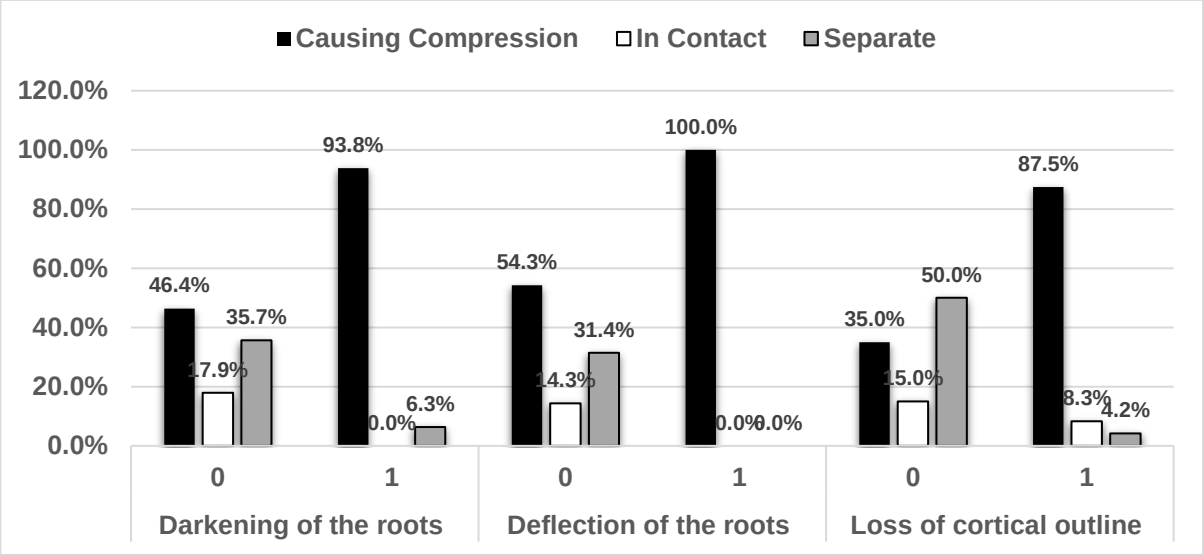

Figure 7 Bar graph demonstrating the statistically significant results in the consistency rate between panoramic findings and CBCT results for female patients

Narrowing of the roots and bifid roots had the least accurate correlation with the CBCT findings. This result may be related to the rarity of these findings because they are reported to occur in only 7% of cases (Jadu et al., 2017). Because the ability to detect changes in density appears to be relatively easier, darkening of the roots was also a significant finding that correlated well between the two imaging modalities, especially for older patients and females (Perschbacher et al., 2010; Stheeman et al., 1996).

The results of this study bring us a step closer to understanding the consistency in the imaging findings that were obtained from panoramic radiographs and CBCT examinations. However, the evidence is still not conclusive and more research is needed in this regard. Future directions should include a correlation between imaging findings and surgical findings, and include a follow-up period of at least 6 months so that more robust results are reached and a more definitive answer can be attained regarding the best imaging modality to predict against IAN injury before mandibular third molar extraction.

5. CONCLUSION

Only some of the imaging signs that predict IAN injury in digital panoramic radiographs were consistent with canal compression findings on CBCT images. Further correlation with surgical findings is necessary.

Clinical significance

These results bring us closer to understanding the difference in diagnostic information provided by digital panoramic radiographs (2D) and CBCT examinations (3D) and the influence of this information on predicting IAN injury prior to mandibular third molar extraction.

Conflict of interest

All authors declare no conflict of interest.

Financial resources

This project did not receive any financial assistance from any source.

REFERENCE

1. Ali, A. S., Benton, J. A., & Yates, J. M. (2018). Risk of inferior alveolar nerve injury with coronectomy vs surgical extraction of mandibular third molars-A comparison of two techniques and review of the literature. J Oral Rehabil, 45(3), 250-257.
2. Bundy, M. J., Cavola, C. F., & Dodson, T. B. (2009). Panoramic radiographic findings as predictors of mandibular nerve exposure following third molar extraction: digital versus conventional radiographic techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 107(3), e36-40.
3. Eyrich, G., Seifert, B., Matthews, F., Matthiessen, U., Heusser, C. K., Kruse, A. L., Lubbers, H. T. (2011). 3-Dimensional imaging for lower third molars: is there an implication for surgical removal? J Oral Maxillofac Surg, 69(7), 1867-1872.
4. Huang, C. K., Lui, M. T., & Cheng, D. H. (2015). Use of panoramic radiography to predict postsurgical sensory impairment following extraction of impacted mandibular third molars. J Chin Med Assoc, 78(10), 617-622.
5. Jadu, F. M., Alhazmi, D., Badr, F. F., & Jan, A. M. (2017). Quantitative assessment of mandibular canal compression assessed by cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol, 124(4), 413-419.
6. Korkmaz, Y. T., Kayipmaz, S., Senel, F. C., Atasoy, K. T., & Gumrukcu, Z. (2017). Does additional cone beam computed tomography decrease the risk of inferior alveolar nerve injury in high-risk cases undergoing third molar surgery? Does CBCT decrease the risk of IAN injury? Int J Oral Maxillofac Surg, 46(5), 628-635.
7. Kushnerev, E., & Yates, J. M. (2015). Evidence-based outcomes following inferior alveolar and lingual nerve injury and repair: a systematic review. J Oral Rehabil, 42(10), 786-802.
8. Nakamori, K., Fujiwara, K., Miyazaki, A., Tomihara, K., Tsuji, M., Nakai, M., Hiratsuka, H. (2008). Clinical assessment of the relationship between the third molar and the inferior alveolar canal using panoramic images and computed tomography. J Oral Maxillofac Surg, 66(11), 2308-2313.
9. Park, W., Choi, J. W., Kim, J. Y., Kim, B. C., Kim, H. J., & Lee, S. H. (2010). Cortical integrity of the inferior alveolar canal as a predictor of paresthesia after third-molar extraction. J Am Dent Assoc, 141(3), 271-278. doi:10.14219/jada.archive.2010.0160
10. Perschbacher, S. E., Pharoah, M. J., Leake, J. L., Lam, E. W., & Lee, L. (2010). A retrospective analysis of referral patterns for oral radiologic consultation over 3 years in Ontario, Canada. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 109(2), e86-91.
11. Rood, J. P., & Shehab, B. A. (1990). The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg, 28(1), 20-25.
12. Sedaghatfar, M., August, M. A., & Dodson, T. B. (2005). Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. J Oral Maxillofac Surg, 63(1), 3-7.
13. Stheeman, S. E., Mileman, P. A., van't Hof, M., & van der Stelt, P. F. (1996). Room for improvement? The accuracy of dental practitioners who diagnose bony pathoses with radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 81(2), 251-254.
14. Susarla, S. M., Sidhu, H. K., Avery, L. L., & Dodson, T. B. (2010). Does computed tomographic assessment of inferior alveolar canal cortical integrity predict nerve exposure during third molar surgery? J Oral Maxillofac Surg, 68(6), 1296-1303.