ORIGINAL ARTICLE

UDC: 616.314-07
DOI: https://doi.org/10.2298/VSP230302029G

The reliability of dental panoramic tomographs in determining the upper and lower third molar root morphology

Pouzdanost ortopantomograma u proceni morfologije korenova gornjih i donjih umnjaka

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Abstract

Background/Aim. The shortcomings of the orthopantomography (OPG) method and radiographic misinterpretations may lead to poor treatment planning and complications during or after the third molar extraction. The aim of this study was to determine the validity and reliability of OPG findings concerning post-extraction wisdom tooth root morphology, as well as whether the degree of clinical expertise affects assessment accuracy. **Methods.** The cross-sectional study included 200 patients who were referred for third molar extraction. Preoperative OPGs were evaluated by the examiners, who were classified by their level of experience into three groups: students, residents, and professors. True root morphologies were recorded after the extraction, and the accuracy of the assessment was evaluated using various statistical tests. **Results.** The majority of assessments were accurate for the lower and upper third molars with a single root. The professor group was the most accurate when compared to the assessments made by the students and residents (p = 0.0015). Weighted Cohen's kappa (κ_w) values for intra-respondent accuracy gradually increased from the student to professor group (0.06, 0.28, 0.34, respectively). The highest discrepancy in inter-respondent accuracy was determined between the student and professor groups (poor; κ_w = 0.25584). **Conclusion.** In this study, the results that confirm the reliability of the OPG scan for the detection of accurate third molars root morphology have not been achieved. The level of clinical experience affects diagnostic accuracy, but complex clinical cases should be evaluated using different methods.

Key words:
evaluation study; molar, third; radiography, panoramic; tooth root.

Apstrakt

Uvod/Cilj. Nedostaci ortopantomografske (OPT) metode, kao i neadekvatne interpretacije radiografskih snimaka mogu imati za posledicu pogrešno planiranje i komplikacije koje nastaju tokom ili nakon ekstrakcije umnjaka. Cilj rada bio je da se utvrdi validnost i pouzdanost OPT nalaza u proceni morfologije korenova umnjaka nakon ekstrakcije, kao i to da li stepen kliničkog iskustva utiče na preciznost procene. **Metode.** Studija preseka sprovedena je na 200 pacijenata kojima je bila indikovana ekstrakcija umnjaka. Preoperativna OPT procena sprovedena je od strane ispitivača koji su na osnovu nivoa iskustva bili svrstani u tri grupe: studente, specijalizante i profesore. Nakon ekstrakcije umnjaka beležena je morfologija njihovih korena, a preciznost procene izvršena je primenom različitih statističkih testova. **Rezultati.** Najviši procenat uspešnih procena utvrđen je za jednokorene gornje i donje umnjake. Postojala je statistički značajna razlika u pogledu uspešnosti procene profesora u odnosu na procenu studenata i specijalizanata (p = 0,0015). Vrednosti *weighted* Cohen's *kappa* (κ_w) su se postepeno uvećavale idući od grupe studenata ka grupi profesora (0,06, 0,28, 0,34, redom). Najveće razmimoilaženje odgovora postojalo je kada su se poredile grupa studenti i grupa profesori (slabo, κ_w = 0,25584). **Zaključak.** U ovoj studiji nisu pokazani rezultati koji potvrđuju pouzdanost OPT snimka za procenu tačne morfologije korena trećih molara. Nivo kliničkog iskustva utiče na uspešnost procene, ali kompleksnije kliničke slučajeve trebalo bi procenjivati različitim dijagnostičkim metodama.

Ključne reči:
procena, istraživanja; umnjaci; ortopantomografija; zub, koren.

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Introduction

The surgical removal of wisdom teeth is one of the most common oral surgery procedures [1–3]. Indications are numerous, and without disputing the importance of complications that may occur during or after the surgery, it should be emphasized that a well-planned intervention reduces the chances of their occurrence. In addition, well-designed preoperative planning may shorten surgery time and reduce postoperative trauma. Clinical examination supported by radiographic evaluation of tooth angulation, impaction type, and relation to the adjacent anatomical structures is the key factor for proper extraction planning [4–7]. However, the interpretation of X-rays should always be taken into consideration. There are wide variations in root numbers and shapes [8–10]. Those diversities reflect a frequent discrepancy between radiographic presentation and true root morphology (Figure 1 a–j).

Orthopantomography (OPG) is the primary radiographic method usually used in everyday surgical practice [11–16]. It is a two-dimensional image of the lower third of the face, along with teeth and temporomandibular joints. This extraoral tomographic technique provides a clear view of the upper and lower alveolar processes as structures that lie within the focal trough. Structures outside the focal plane are blurred or invisible [17]. Those shortcomings and the insufficiencies for fine anatomical/pathological details should not be neglected during the X-ray analysis [18]. Additionally, image distortion, magnification, and the superimposition of different structures may mislead the clinician [19].

Radiographic misinterpretation might not only be the result of OPG deficiencies but it may also be related to the examiner's experience. Although knowledge is required, clinical practice and training are recommended for proper radiographic judgment [15, 20]. Superimposition, fused or

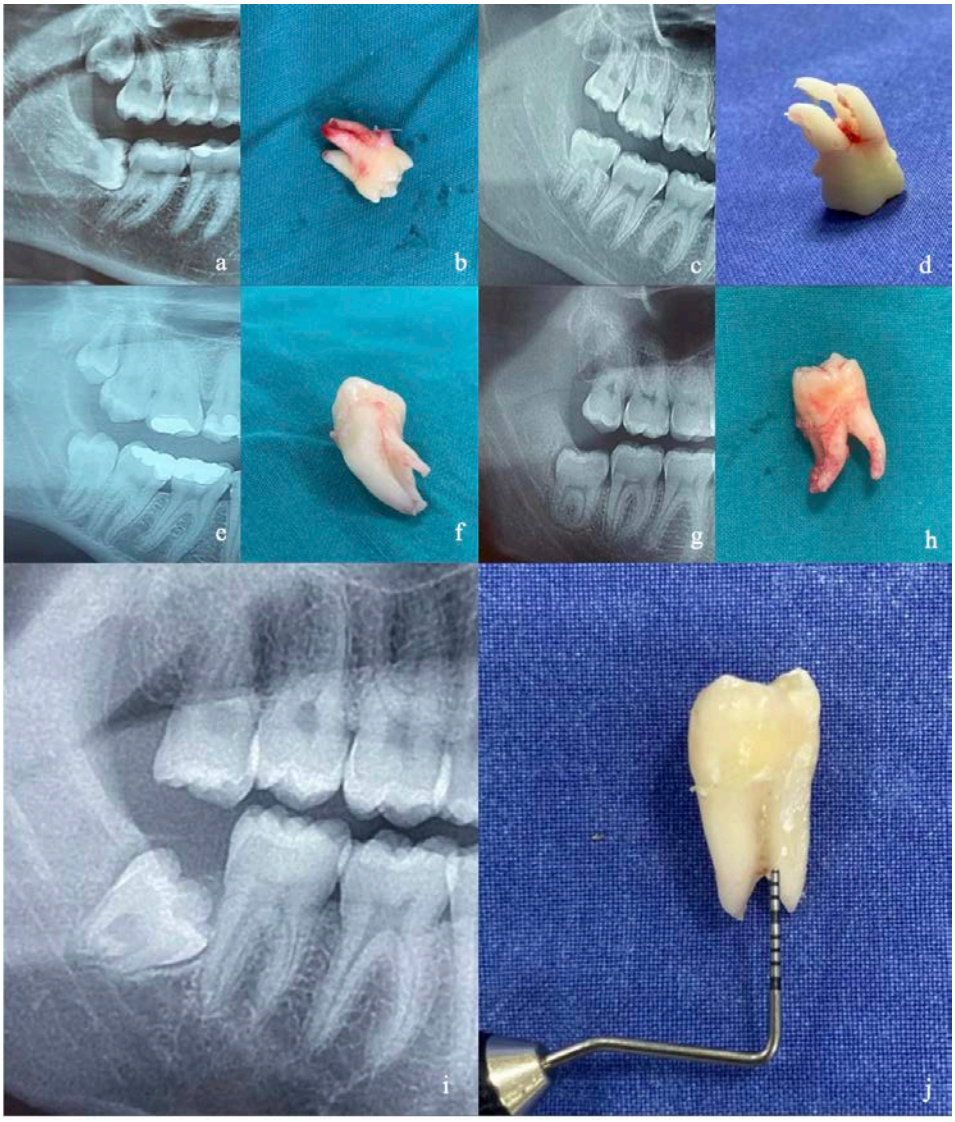

Fig. 1 – The discrepancy between radiographic presentation and true root morphology. Preoperative orthopantomography of lower third molar (a, e) and upper third molar (c, g, i). True morphology of lower third molar (b, f) and upper third molar (d, h, j). Demonstration of incomplete fusion > 3 mm which was considered as separate roots (j).

accessory roots, and dilacerations are burdening factors even for well-trained clinicians and often require additional radiographic methods.

Therefore, the primary aim of this study was to determine the validity and reliability of OPG findings concerning post-extraction wisdom tooth root morphology. Additionally, we wanted to determine whether the degree of clinical expertise affects assessment accuracy.

Methods

The cross-sectional study was carried out at the University of Belgrade, Faculty of Dental Medicine, Clinic for Oral Surgery, Serbia, from October 2021 to October 2022, in concordance with the Helsinki Declaration and with the approval of the local Ethics Committee.

Inclusion and exclusion criteria (participants/examiners)

A total of 265 adult patients were assessed for the study, and 200 met the following inclusion criteria: patients with an indication for the extraction of impacted, semi-impacted, or erupted wisdom teeth; preoperative OPG performed at least three months before the tooth extraction; adult patients over 18 years of age, in good physical and mental condition [American Society of Anesthesiologists (ASA) I classification].

The exclusion criteria were the following: unfinished root formation or the presence of the associated root/tooth pathology; patients with poor oral hygiene; pregnant or breastfeeding women; smokers and drug addicts.

Patients who met the inclusion criteria were informed about the procedure, required radiographic analysis, and utilization of their OPG images for the research. Written consent for participation was obtained from all included patients.

The examiners involved in the study were classified into three respondent groups: student group (20 fourth-year dentistry students that have passed the Radiology exam), resident group (10 residents from the Oral Surgery Department), and professor group (2 full-time professors from the Oral Surgery Department).

The examiners were randomly given an even number of OPGs for the evaluation (10 OPGs per student, 20 OPGs per resident, and 100 OPGs per professor). The randomization process was performed using a table of random numbers for three groups of respondents using an online program [21].

Outcomes

The primary outcome variables were the assessed OPG root number (aOPGrn) and the true post-extraction root number (TRN). The gender and age of the patient and the tooth scheduled for extraction were recorded in the study chart. Each examiner performed a radiographic evaluation separately, and the assumed OPG findings regarding the wisdom tooth root number were recorded. On the day of surgery, several weeks later, after the tooth extraction, the actual number of roots was again recorded by a separate investigator blinded for the examiners' assessments. Fused roots were counted as a single root, and in the case of incomplete fusion, when the roots were more than 3 mm long after the furcation, they were counted individually.

Statistical methods

Data were analyzed using a commercially available software program (SPSS 22.0, IBM Corp., Armonk, NY, USA). Data were summarized by intervention group (*per* protocol analysis). Parameters presented by continuous variables were described using measures of central tendency (mean, median) and dispersion (standard deviation, minimum, maximum). For categorical variables, the frequency and percent in each category were presented and analyzed with a Chi-squared test (χ^2). Inter-rater (Cohen's weighted kappa – κ_w) statistics were done to evaluate the total agreement between the two methods (medcalc ver. 20.104). Sensitivity and specificity tests were utilized to determine the predictive validity of radiographic interpretation.

The sample size and power of the study were calculated in the G*power program (ver. 3.1.9.4. Germany). There is a 95% chance of correctly rejecting the null hypothesis of no difference between expected and observed proportions with 148 participants ($\alpha = 0.01$, dz = 0.37, Df = 2). The *post-hoc* achieved power was 98.8% for 200 participants [difference between two frequencies (Goodness-of-fit tests: Contingency tables), $\alpha = 0.05$, Df = 2]. The level of significance was set at 0.05.

Results

The study included 200 patients, 95 (47.5%) of whom were men and 105 (52.5%) were women. The patients' ages ranged from 17 to 28 years (20.99 ± 2.51 on average). For the male patients, the average was 21.41 ± 2.50 years and 20.60 ± 2.48 years for females.

Out of the 200 extracted third molars, 64 had a single root, 109 had two roots, 22 had three, and just 5 had four roots (Table 1).

Table 1

Wisdom tooth root number distribution

Third molars	One root	Two roots	Three roots	Four roots	Total
Upper	49	33	15	3	100
Lower	15	76	7	2	100
Total	64 (32)	109 (54.5)	22 (11)	5 (2.5)	200 (100)

All values are expressed as numbers (percentages).

When comparing the upper and lower wisdom teeth, the frequency of the correct assessments varied. The incidence of improper OPG interpretation increased with the root number (Table 2).

Sensitivity and specificity tests describing the accuracy of the correct assessment for each respondent group are presented in Table 3. A statistically significant difference in correct assessment of OPG relating to the TRN was found in the student group for two- and three-rooted third molars (p = 0.001, p = 0.000, respectively), as well as for the two-rooted molars in the resident group (p = 0.009).

Among the 200 teeth, 65 (32.5%) were evaluated radiographically correctly by all three respondents. In 43.5% of cases, the estimation was discordant (two respondents had the same correct assessment, but the third was incorrect). All three respondent groups failed to evaluate correctly 48 (24%) teeth.

The compliance between aOPGrn and wisdom tooth TRN for all three respondent groups is presented in Table 4. The professors' respondent group had the highest percentage (63%) of correct OPG assessments, while the students' group had the lowest (46.5%) performance. There were statistically significant differences between the groups' correct answers (p = 0.0015).

The respondents' reliability in making a correct OPG assessment was measured through intra-respondent accuracy (Table 5). There was a gradual increase in κ_w values from the first to the third group (0.06, 0.28, and 0.34, respectively). The students' reliability was accessed as poor (κ_w < 0.20), while the residents' and professors' reliability were accessed as fair (κ_w between 0.21 and 0.40). Inter-respondents' concordance in OPG assessments demonstrated the highest discrepancy between the student and professor groups (poor; κ_w = 0.25584).

Discussion

The OPG is not a reliable radiographic method for third molar root assessment [1]. Due to the lack of a third dimension on OPG, there are many mismatches between radiographic assessments and the true wisdom tooth root morphology. However, the level of clinical expertise and OPG interpretation experience affects assessment accuracy.

Table 2

The frequency of the correctly assessed orthopantomography root number

Third molars	One root	Two roots	Three roots	Four roots
Upper	43.5	35.3	42.2	22.2
Lower	51.1	40.4	19	0

All values are expressed as percentages.

Table 3

Sensitivity and specificity tests

Root number	Student group		Resident group		Professor group	
	sensitivity	specificity	sensitivity	specificity	sensitivity	specificity
One	45.3	52.9	56.3	37.5	68.8	39.7
Two	57.8*	67.0*	68.8‡	49.5‡	63.3	37.4
Three	4.5†	48.3†	40.9	37.1	54.5	36.0
Four	0.0	52.3	20.0	38.5	20	35.9

Statistically significant differences: *p = 0.001; †p = 0.000; ‡p = 0.009.
All values are expressed as percentages.

Table 4

The compliance between aOPGrn and TRN for the three respondent groups

Parameter	Student group	Resident group	Professor group	Total
True	93 (46.5)	121 (60.5)	126 (63.0)	340 (56.7)
False	107 (53.5)	79 (39.5)	74 (37.0)	260 (43.3)
Total	200 (100)	200 (100)	200 (100)	600 (100)

aOPGrn – assessed orthopantomography root number; TRN – true post-extraction root number.
All values are expressed as numbers (percentages).

Table 5

Intra-respondents' accuracy in orthopantomography assessment and inter-respondent concordance

Parameter	Intra-respondents accuracy			Inter-respondents compliance		
	student group	resident group	professor group	students/residents	residents/professors	students/professors
κ_w values	0.06	0.28	0.34	0.41	0.41	0.25

κ_w – weighted kappa. κw and strength of agreements: < 0.20 – poor; 0.21–0.40 – fair; 0.41–0.60 – moderate; 0.61–0.80 – good; 0.81–1.00 – very good.

In permanent dentition, the upper and lower third molars are the teeth with the widest range of morphological variations [12]. In our study sample, similar to the studies of Bell et al. [1], Zhang et al. [9], and Tomaszewska et al. [10], the majority (49%) of upper ones had a single root, compared to the lower ones that were mostly (76%) two-rooted. With the root numbers increasing, there was a higher chance of OPG misinterpretation, which came to attention, especially in multirooted lower third molars. They usually had mesial and distal roots and were easily recognized as two-rooted teeth. However, in the cases when they had three or four roots, they were correctly recognized in only 19% and 0%, respectively. Upper third molars, on the other hand, were typically identified as single or three-rooted teeth.

The present study discovered differences in sensitivity among participating respondent groups. Sensitivity was significantly higher for the assessment of two-rooted teeth within the resident and professor groups. That could be due to the prevalence of third molar root morphology and the ease of precise identification on OPG images. On the contrary, the student group demonstrated significantly lower sensitivity when assessing three-rooted and four-rooted teeth. We assumed that the main reason for that was inexperience and that the complex root morphology required a refined manner of OPG observation and interpretation. Moreover, experienced observers probably rely on previous observations, making it easier to predict the true root morphology.

In everyday practice, dentists mostly interpret X-rays by themselves, and it is assumed that the precision of OPG assessment directly depends on years of clinical experience and expertise [15]. When observing different respondent categories, we found that the professor group had the highest (63%) percentage of correct answers, followed by the residents (60.5%) and the students (46.5%). One of the reasons might come from the fact that those who extracted a lot of wisdom teeth experienced accessory root fractures, different failures, and complications during the extractions and developed practical skills and experience for improved radiographic evaluation. With time, they adopt an explicit vision and become sensitive to details that are overlooked by the less experienced doctors. They incorporate acquired knowledge and expect the worst from every wisdom tooth extraction. For that kind of clinician, it is of essential value to determine, for instance, if the upper wisdom tooth is three-rooted or if the lower one has two mesial roots. Unexperienced students are not aware of those anatomical varieties and have not developed skills for radiographic detail recognition. Because of that, in this study, they were evaluated as having poor diagnostic accuracy ($\kappa_w = 0.06$).

Inter-respondent compliance in the assessment among the groups was consistent. Although the different κ_w values supported the idea of clinical experience importance, the professors/residents group ($\kappa_w = 0.41$) and the professors/students group ($\kappa_w = 0.25$) had a fair assessment match. In other words, the greater the experience, the fewer the discrepancies in the OPG interpretations among observer groups. Those findings are supported by the study of Richter et al. [15], who stated a strong relationship between the number of images read and diagnostic accuracy.

All the patients included in the study had preoperative OPG, although not all images were taken at the same radiology center. That could imply that the quality of the OPGs was not the same for all the patients. Additionally, frequent eccentric tooth positions, root dilacerations, fusions, and number variations were the contributing factors to low diagnostic reliability [1]. Nevertheless, the overall number of false assessments was similar to those described in the literature. Even for the experts, the error rates may vary from 19% to 41% [15, 20]. After all, it is not easy to perform a correct OPG evaluation, and misinterpretations may occur even with trained eyes. That is one of the reasons why clinicians must always be aware and cautious. Whenever in doubt, whenever the root anatomy is not easily recognized and may differ from the one presented on the OPG, the clinician should consider additional radiographic methods for precise assessment. In conditions where the wisdom tooth is deeply impacted close to the alveolar inferior bundle, close to the maxillary sinus, or when other pathologies are present, indications for the cone beam computer tomography (CBCT) radiographic method should be considered [16]. CBCT is the best and most accurate method for wisdom tooth root assessment. However, the radiation exposure is much higher than OPG, so the indication for CBCT has to be reserved for the designated conditions [5]. The surgeons should aspire to minimize the occurrence of complications during or after third molar extraction by approaching every case individually and making decisions based on a thorough clinical and radiographic examination. They should be able to recognize complex morphology cases requiring detailed radiographic analysis, which exceeds the capabilities of OPG images.

Conclusion

In the majority of cases, the reliability of the OPG method for the evaluation of wisdom tooth root number and morphology is insufficient. The level of clinical experience and expertise affects diagnostic accuracy, but complex clinical cases should be evaluated by different, more accurate methods, i.e., CBCT images.

Conflicts of interest

The authors declare no conflict of interest.

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Received on March 2, 2023
Revised on April 9, 2023
Accepted May 23, 2023
Online First May 2023