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Variations in the anatomical positioning of impacted mandibular wisdom teeth and their practical implications

KEYWORDS
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computer tomography,
norm variations

SUMMARY

Surgical removal of impacted third molars is one of the most frequent procedures in oral surgery. Here, three-dimensional (3D) imaging is often used, yet its necessity is still being heavily debated. The aim of the study was to describe the variation in the anatomical positioning of third mandibular molars, and, by doing so, examine the necessity of 3D imaging. A retrospective case study was performed with the patients from an oral surgery department from January 2009 to February 2013. The primary focus of the study was on the spatial relationship to the mandibular canal, as well as angulation, root configuration, and developmental stage of the wisdom tooth. Descriptive statistics were calculated for these variables.

A total of 1197 wisdom teeth in 699 patients were evaluated. 46.7% exhibited direct contact to the mandibular canal, another 28.7% showed close proximity and 24.6% a measurable distance. In 29.0%, the mandibular canal was vestibular and in 23.8% lingual to the wisdom tooth. In 7.4%, it was interradicular and in 0.6% intraradicular. Most teeth had one (21.3%) or two (55.3%) roots. Others had three (17.6%), four (2.0%) or five (0.2%) roots. In 31.4% of the teeth, the root perforated the lingual compact bone, and in 4.3% the vestibular compact bone. 44.4% of the teeth had mesial angulation, 9.7% distal angulation, 35.3% lingual and 2.9% buccal angulation. Due to the anatomical variety, the use of 3D imaging is recommended before surgical removal of mandibular third molars if conventional imaging cannot exclude complicated conditions.

Introduction

The surgical removal of impacted third molars is – along with implantation measures – the most common surgical procedure in oral and maxillofacial surgery. Injuring the inferior alveolar nerve is rare but typical of this specific surgical procedure (Susarla & Dodson 2007). The patient's age, the surgeon's experience and how deeply the tooth is impacted are influential factors (Haug et al. 2005; Blondeau & Daniel 2007; Baqain et al. 2008).

After computer tomography (CT) was developed (Cormack 1963; Cormack 1964; Hounsfield 1973), it was also used to image impacted wisdom teeth (Jaquiery et al. 1994; Engelke et al. 1997). Since cone beam tomography (CBT) was introduced, the importance of 3D imaging has increased dramatically when dealing with impacted teeth. For example, the relation between the mandibular third molars and the inferior alveolar nerve has often been the subject of scientific research (Nakagawa et al. 2007; Susarla & Dodson 2007; Nakamori et al. 2008; Tantanapornkul et al. 2009).

Especially in situations presenting the classical risk factors in orthopantomograms (Rood & Shehab 1990), it seems essential to know the exact 3D anatomy of every individual patient, not only to assess how great the risks are and to obtain the patient's informed consent but also to adapt the surgical strategy if necessary.

The aim of the study was to examine the occurrence and frequency of variations in the anatomical positioning of mandibular wisdom teeth that are in close proximity to the mandibular canal. Special attention was paid to the positioning of mandibular third molars in relation to the mandibular canal, because it is one of the most relevant risks of complication.

Materials and Methods

The authors developed and examined a retrospective case study to fulfill the purpose of the research. Everyone who attended the Clinic for Oral Surgery of a Swiss university between January 2009 and February 2013 for evaluation and treatment of their wisdom teeth was part of the study sample. To be included in the study, all patients had to undergo 3D imaging of the area in question. If a precise evaluation of the study parameters was not possible with the 3D image, the patient was excluded from the study sample.

The CBT used was a KaVo 3D eXam (KaVo Dental AG, Brugg, Switzerland). Without taking other factors into account, a resolution (voxel size) of 0.4 mm was used for wisdom tooth diagnostics. At 90–120 kVp and 3–8 mA (pulsed), the recording time was 8.5 seconds.

The assessment was performed using a computer (HP Compaq 6200 Pro Microtower PC, display card: Intel HD Graphics 2000 Dynamic Video Memory Technology, mouse: HP Compaq DC 172B; Hewlett Packard, Palo Alto/CA, USA) with a calibrated monitor (HP Compaq LA 2306x; Hewlett Packard, Palo Alto/CA, USA). Further, the reconstruction software eXamVision version 1.9.3.13 (KaVo Dental GmbH, Biberach/Riss, Deutschland) was used.

The evaluation was carried out during a 4-week period by an assistant dentist who has a total of six years of work experience, and is in his third year of training to become a specialist in oral surgery. At the end of the assessment phase, any uncertainties were evaluated again with the help of the Head of Dentomaxillofacial Radiology department (senior surgeon with post-doctoral qualification ["habilitation"], specialist for oral and maxillofacial surgery, eleven years of work experience, CBT instructor).

In order to best evaluate the image on the monitor, it was improved as much as possible by adapting the contrast. Then, using the following system, the evaluation was conducted. If necessary, the light and contrast configurations were adapted further during evaluation.

The following criteria were examined:

- spatial relationship between the wisdom tooth and the mandibular canal (evaluation in arbitrary layers, mainly coronal)
  - mandibular canal apical to the tooth structure
  - mandibular canal buccal
    - lingual compact bone intact
    - nerve runs through the lingual compact bone
  - mandibular canal lingual
    - lingual compact bone intact
    - nerve runs through the lingual compact bone
  - mandibular canal between apically open roots (mandibular canal runs interradicularly)
  - mandibular canal through apically closed root (mandibular canal runs intraradicularly)
  - direct contact of tooth and mandibular canal (Fig. 1)
  - close proximity of tooth and mandibular canal (Fig. 2)
  - cancellous space between tooth and mandibular canal (Fig. 3)
- diameter of the mandibular canal (evaluation in the coronal layer)
  - constant diameter, circular (Fig. 3)
  - slight constriction, oval (Fig. 2)
  - considerable constriction, flat (Fig. 1)
- anatomy of the tooth roots
  - immature roots (evaluation in the sagittal layer)
  - fully formed roots (evaluation in the sagittal layer)
  - number of root tips (evaluation in the sagittal and coronal layer)
  - parts of root perforate the lingual compact bone (evaluation in the coronal and axial layer)
  - no perforation of the lingual compact bone by any part of the root (evaluation in the coronal and axial layer)

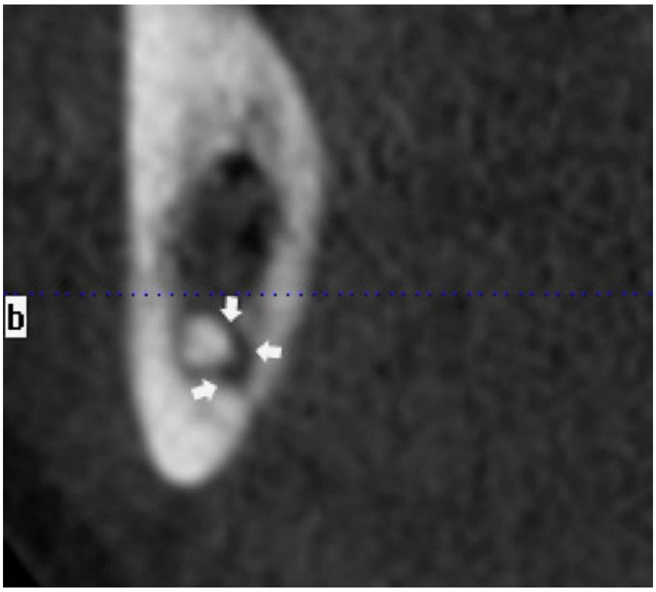

Fig. 1 Example of *direct* contact between the mandibular canal and the mandibular third molar; flat cross section; white arrows = mandibular canal (coronal plane of tooth 48).

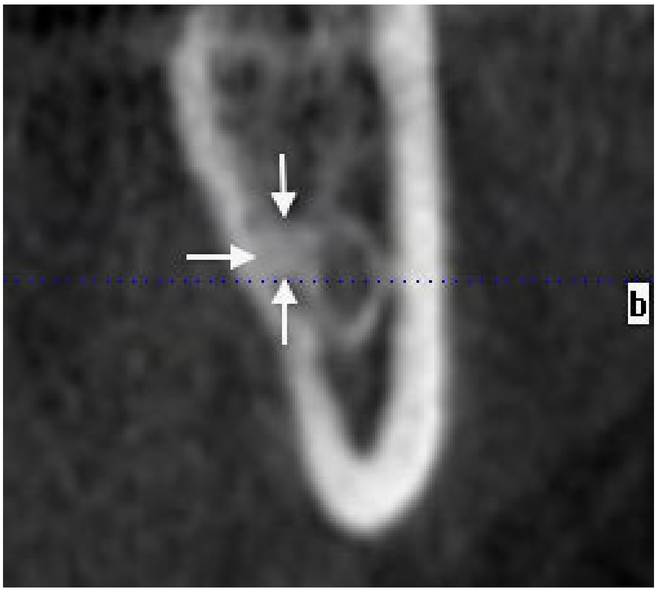

Fig. 2 Example of *close proximity* of mandibular canal and mandibular third molar, the border between canal and root tips is still discernable, oval cross section; white arrows = section of tooth root 38 (coronal plane of tooth 38).

- type of tooth impaction (evaluation in the sagittal and coronal layer)
- angulation of the tooth
  - mesio-distal (evaluation in the sagittal layer)
  - bucco-lingual (evaluation in coronal layer)
- basic demographic data
  - age
  - sex
  - side

Furthermore, existing pathologies of the area involved were analyzed (see Tab. VI).

To evaluate the spatial relation of the mandibular canal to the mandibular third molars, the orientation was adapted, if necessary. The spatially smallest relation was always evaluated and divided into three categories, as follows. 1. If cancellous structures between the mandibular canal and the tooth could be seen, and the mandibular canal showed no direct contact to the tooth, this counted as a clearly measurable distance (Fig. 3). 2. If the mandibular canal was directly adjacent to the tooth, but a delimitation was still visible in the coronal image, it was defined as being in close proximity (Fig. 2). 3. Cases where such a delimitation was no longer visible were defined as being in direct contact (Fig. 1).

The canal's cross-sectional shape was evaluated on the coronal plane of the Dentascan reconstructioned image where it had the smallest tooth-to-mandibular canal distance. The canals were round (Fig. 3), oval (Fig. 2), or flat (Fig. 1).

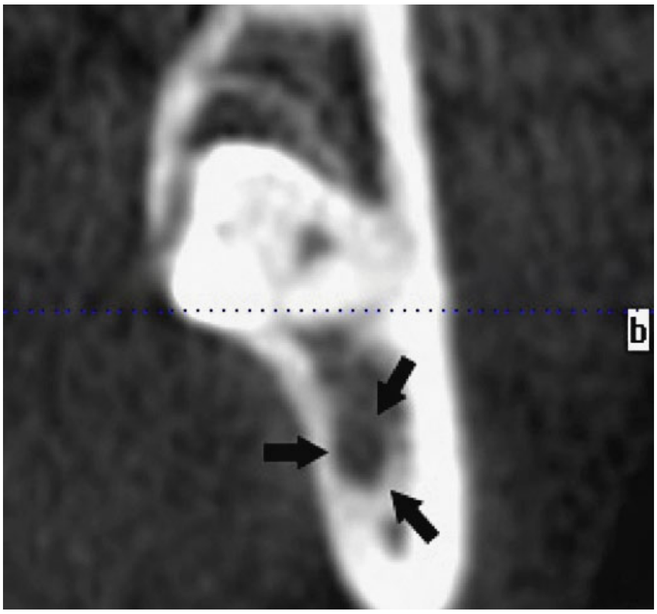

Fig. 3 Example of a *measurable distance* between mandibular canal and mandibular third molar; round cross section; black arrows = mandibular canal (coronal plane of tooth 38).

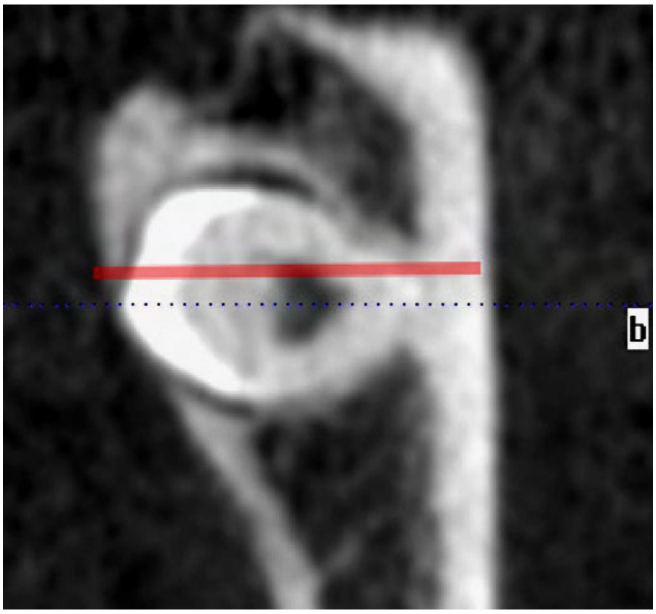

Fig. 5 Measuring the coronal angulation: first the axis of the third molar is determined in the Dentascan (red line).

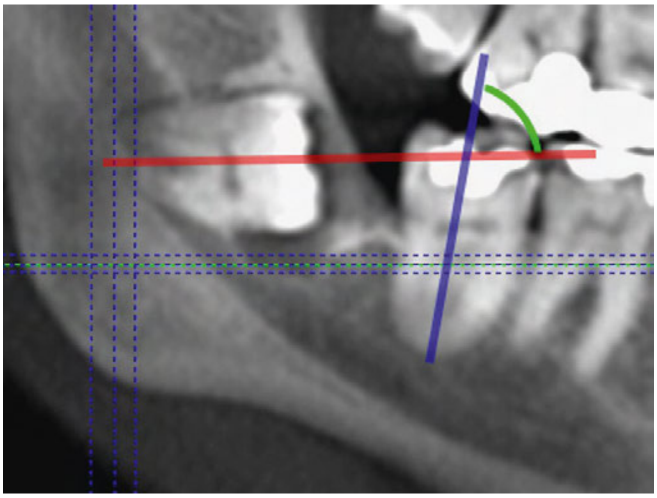

Fig. 4 Measuring the sagittal angulation: angle (green), between the tooth axes of the third molar (red line) and the second molar (blue line) on the reconstructed orthopantomogram.

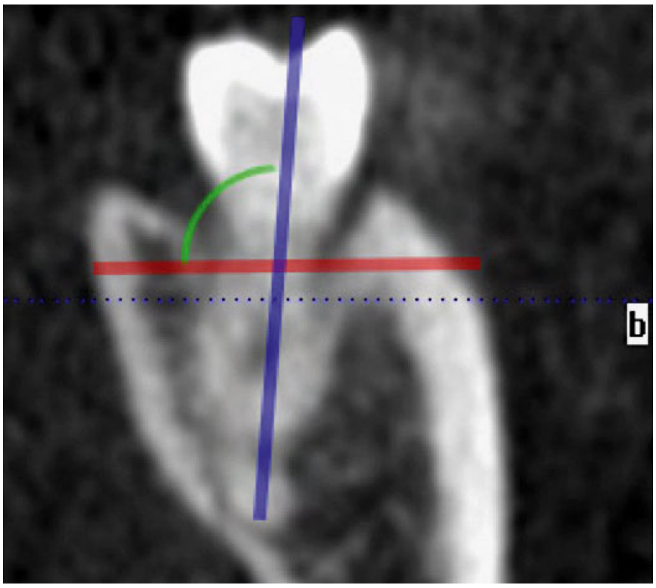

Fig. 6 Measuring the coronal angulation: determiniation of the axis of the second molar (blue) on a Dentascan located further mesially. Definitive determination of the angulation angle (green); red = tooth axis of the third molar in Figure 5.

To determine the angulation in the sagittal direction, an angle scale was superimposed on the reconstructed panoramic tomographic image, dividing the angulation into 5-degree steps. The reference axis was the longitudinal axis of the second mandibular molar in positional relationship to the longitudinal axis of the third mandibular molar (Fig. 4).

The evaluation of the angulation on the coronal plane was determined via the Dentascan reconstructioned image. In order to do so, the level of the third mandibular molar was located and the longitudinal axis of the tooth was determined. Afterwards, the mesial plane of the second mandibular molar was located and its longitudinal axis determined. The deviation between these two corresponded to the angle in question, which was determined using a superimposed angle scale divided into 5-degree steps (see Fig. 5 and 6).

To count as fully formed roots, the apex still had to be open and the growth process of the root had to have advanced more than halfway. A tooth was classified as being a tooth bud if the crown or root were developed less than halfway. The length of the roots of the neighboring teeth served as a reference.

By using Excel, Office for Mac 2008 (Microsoft Corp, Redmond, WA, USA), descriptive statistics were calculated for all of these parameters.

All the evaluated data were collected during clinical treatment. All patients consented to their data being used for the purpose of the study. Thus, the study fulfills the criteria listed in paragraphs 4a and b of the guidelines (version 21.5.2010) of the responsible Canton's Ethics Committee and is thus exempt from having to submit an individual ethics proposal. Consequently, the design of the study also conforms to the guidelines of the Declaration of Helsinki (Declaration of Helsinki concerning Ethical Principles for Medical Research involving Human Subjects).

Results

In total, 699 patients (1197 wisdom teeth) fulfilled the criteria needed to participate in the study. No one had to be excluded retrospectively. Therefore, 100% of the CBT images could be used to asses the question at hand.

In terms of gender distribution, 49.1% of the patients were female (n=343) whereas 50.9% were male (n=356). 50.5% of the impacted teeth were found in female patients (n=605) and 49.5% in male patients (n=592). 51.2% of the teeth were on the left (n=613) and 48.8% were on the right side (n=584). The average age was 28.4 years when the CBT image was made (minimum=8, maximum=89, standard deviation=12.1 years) (Tab. I). Figure 7 shows the age distribution.

A re-evaluation of uncertain findings was not necessary. 81 hours were needed to evaluate the images. Thus, approxi-

Tab. I Demographic data of the study sample

	relative frequency (%)	absolute frequency (n)
number of patients	100.00	**699**
female	0.49	343
male	0.51	356
number of teeth	100.00	**1197**
female	0.51	605
male	0.49	592
left (#38)	0.51	613
right (#48)	0.49	584

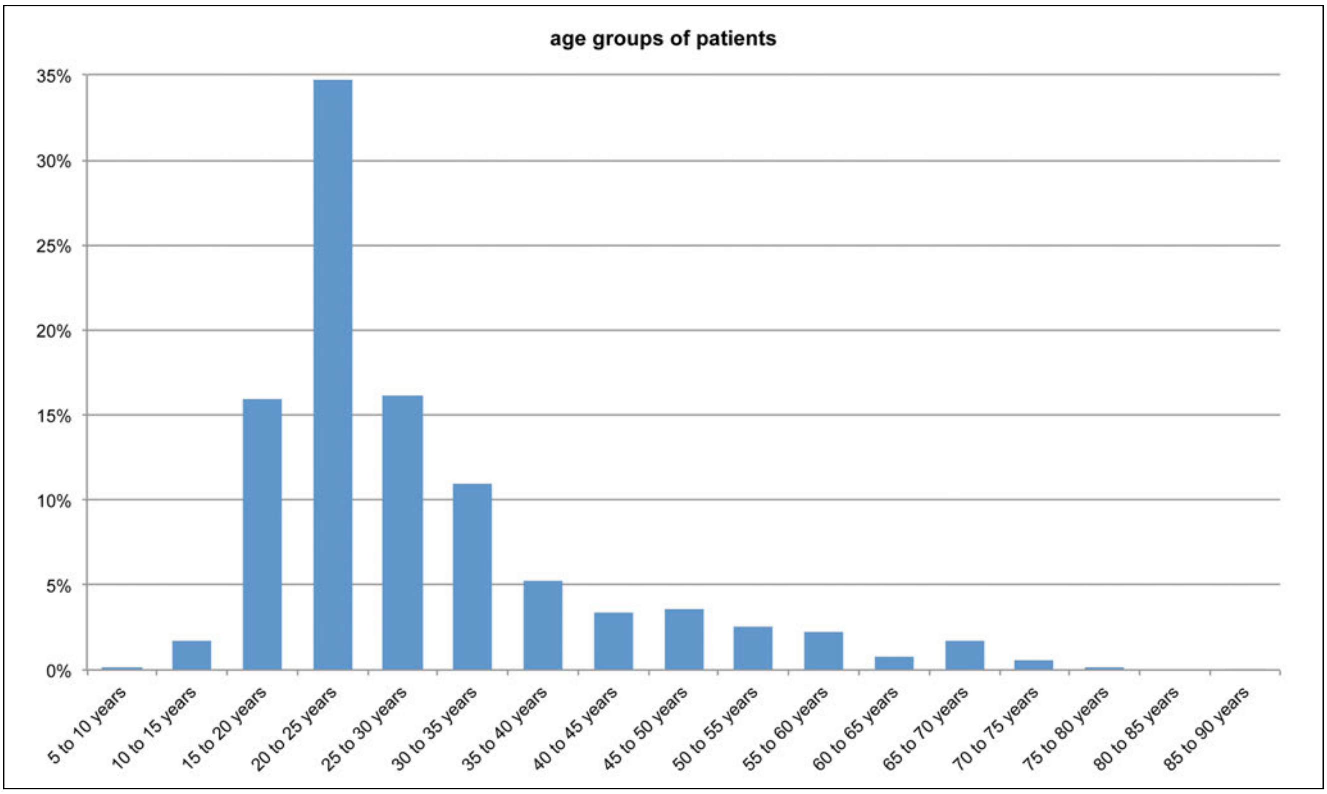

Fig. 7 Age distribution of the study population

mately four minutes were needed to evaluate each tooth region (assuming there was a certain learning curve concerning the sequence of steps in the analytical process, etc).

Regarding the three-dimensional spatial relationship between the tooth and the mandibular canal, there was direct contact between these structures in 46.7% (559 teeth) of the cases. 344 teeth (28.7%) were in close proximity to the mandibular canal (Fig. 8), and 23.6% were found to have a constriction with a flat cross section in the area of contact.

347 teeth (29%) showed a buccal course of the manibular canal and 285 (23.8%) showed a lingual one. 89 (7.4%) of the teeth had at least one root on each side of the mandibular canal (interradicular course), and parts of seven teeth (0.6%) were found on both sides of the mandibular canal but caudal to this were fused again (intraradicular course). All other nerve canals (469, 39.2%) were located apically in relation to all parts of the teeth. The spatial relationship between tooth and nerve is depicted in Figure 8.

In 1004 (83.9%) of the examined teeth, the roots were fully formed. Most of the mandibular third molars had two roots (662, 55.3%), a few had one root (255, 21.3%) and some had three (211, 17.6%). Only 24 teeth (2%) had four roots. Two mandibular third molars (0.2%) were identified as having five roots.

Most teeth were angled towards the mesial (44.4%, 531) or stood vertically (45.9%, 550) without any substantial angulation. Merely 116 teeth (9.7%) stood at a distal angle. In the coronal plane, 423 (35.3%) teeth had a lingual angulation and 35 (2.9%) had a buccal one. Consequently, most teeth did not show any kind of angulation on this plane. The angulation is depicted in Figures 9 and 10.

The roots of 376 (31.4%) teeth were found to perforate the lingual compact bone, whereas the roots of 51 (4.3%) teeth perforated the buccal compact bone.

Tables II to V present an overview of these anatomical variations.

On the vast majority of the CBT images – 70.9% (n=849) – no local pathologies were found. The pathologies most commonly found were caries (12.2%; n=146), pericoronal lesions (6.4%; n=76), lesions on the second molar (5.0%; n=60), and apical lesions (2.1%; n=25).

Table VI gives an overview of these pathologies.

Discussion

The purpose of this study was to describe the frequency of variations in the anatomical positioning of third mandibular molars in patients whose orthopantomograms indicated a high risk of injury to the inferior alveolar nerve.

The quality of all CBT images included in the study was sufficient to prevent retrospective exclusion based on non-evaluability. This was possible despite the fact that the setting of spatial resolution was relatively low for CBT standards (0.4 mm voxel edge length), due to radiation safety considerations. It was also not necessary for a physician experienced in dealing with CBT to evaluate the images, and it was possible to evaluate the recorded parameters without doubt or uncertainties. This is confirmed by the relatively short period of time (four minutes) it took to evaluate each individual area of affected teeth. Had the evaluation of the pictures been more difficult, it would no doubt have required more time. Consequently, the relatively low setting of spatial resolution was sufficient for the problem at hand.

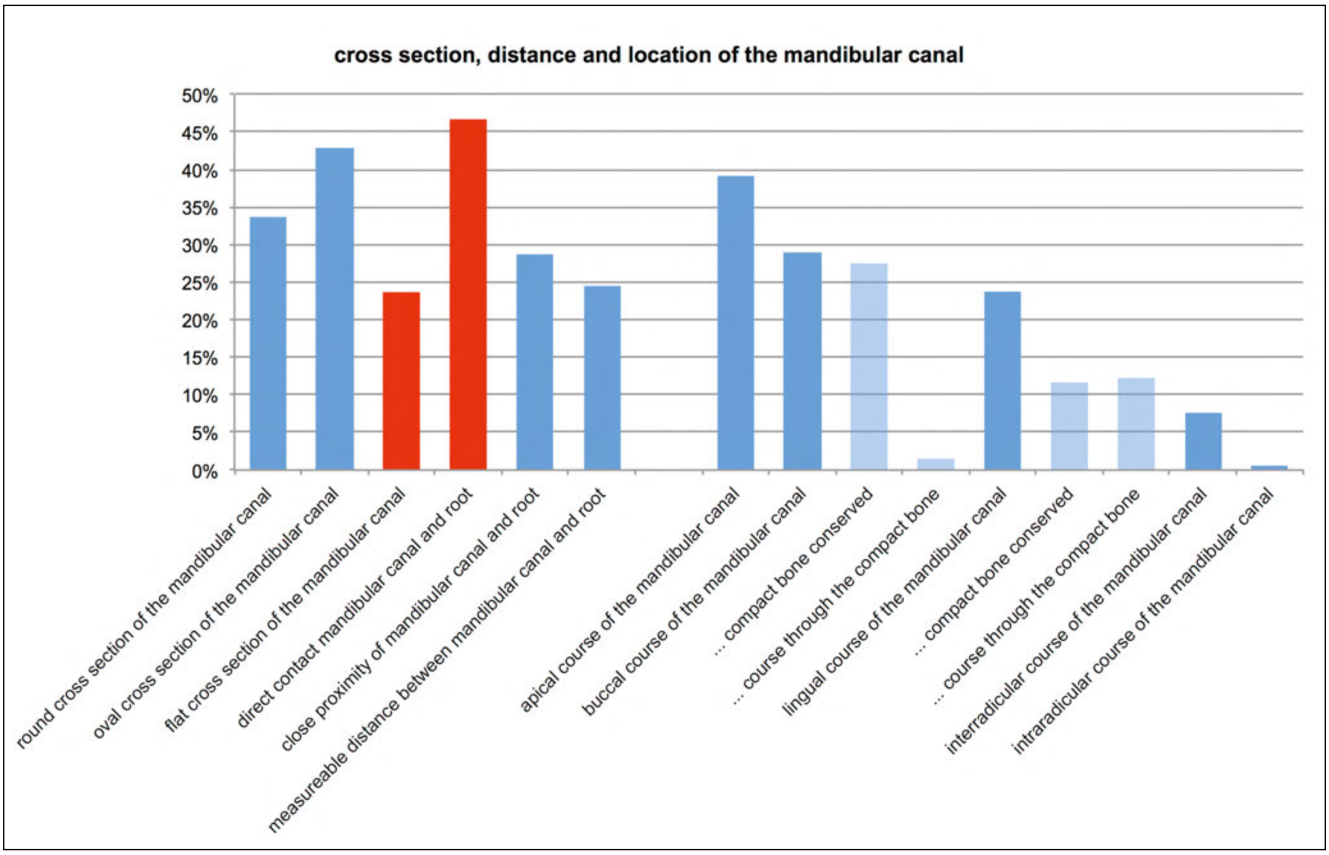

Fig. 8 Graphical representation of the cross section, distance and location of the mandibular canal; light blue bars = subgroups of the dark blue bars to their left; red bars = independent risk factors for postsurgical lesions of the inferior alveolar nerve in accordance with Eyrich et al. (Eyrich et al. 2011)

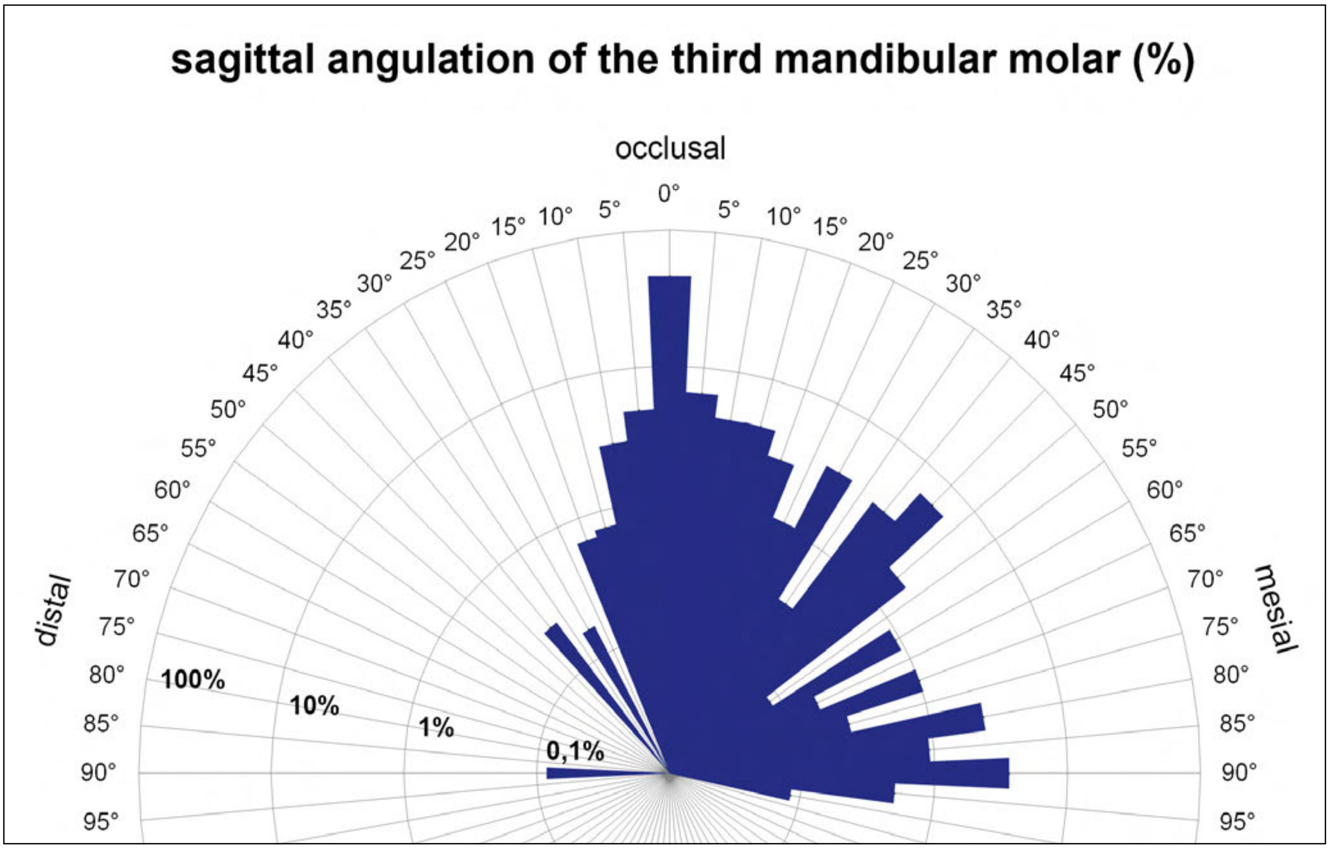

Fig. 9 Distribution of the angulation in mesial-distal direction (sagittal section) (logarithmic scaling).

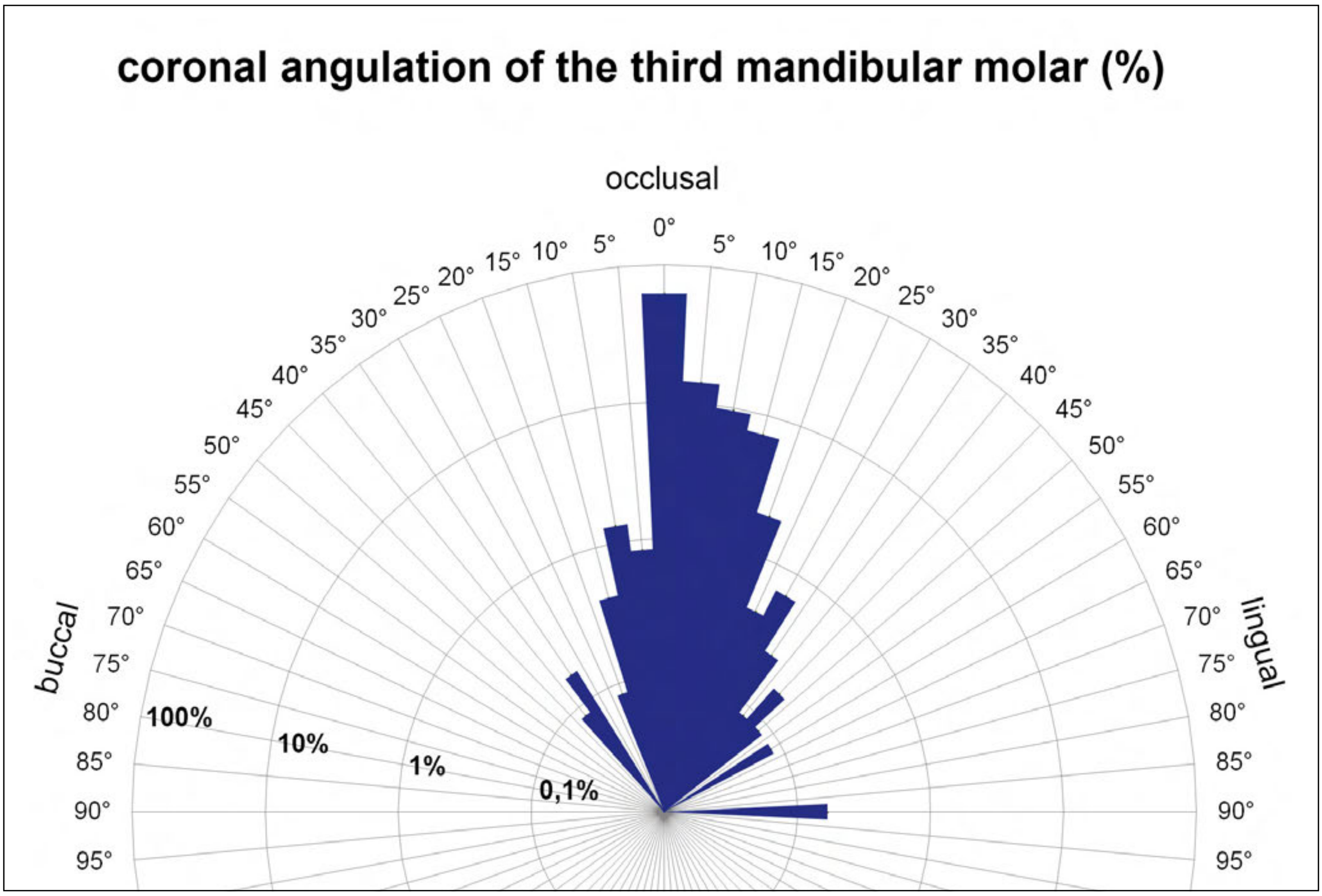

Fig. 10 Distribution of the angulation in buccal-lingual direction (coronal section) (logarithmic scaling).

The authors considered the possibility to create a slanted section – with a tangential view of the mandibular canal, by which it can be clearly identified – and of course a clearly defined question as decisive for problem-free evaluation of the images (Lubbers et al. 2012). Having access to the volume with the option of selecting individual slices should be the standard today (Lubbers et al. 2011b). Especially the volume dataset (in the standardized data format) is indispensable, even if it is meant for further processing in other software programs and applications, such as for implant planning.

The distribution according to sex and side was quite even. The age distribution is in accordance with what is typical for problems related to wisdom tooth and corresponds to the international guidelines of possible prophylactic removal of wisdom teeth. This was – without evaluating this question in detail – the most common reason for patients to frequent the department. Thus, the study sample can be considered representative.

In about a tenth of the cases, the course of the mandibular canal was inter- or intraradicular. This result essentially concurs with those of other studies that have the same criteria (Maegawa et al. 2003; Mahasantipiya et al. 2005; Ohman et al. 2006; Tantanapornkul et al. 2009; Lubbers et al. 2011a). The numbers are essentially valid for the subcategories of mandibular third molars with 2D risk indicators as Rood and Shehab describe them (Rood & Shehab 1990). This is the relevant subcategory when dealing with potential damage to the inferior alveolar nerve caused by surgery.

The many variations of the course (of the mandibular canal) are conspicuous regarding the other distributions. Vestibular and lingual courses of the mandibular canal were about equally common. Thus, there is no typical location of the nerve, which is in accordance with previous studies (Eyrich et al. 2011; Lubbers et al. 2011a). Those studies, however, did not include an apical course because the criteria were more specific. This means that all other situations (assuming there is a comparable relative distribution) correspondingly occur more frequently.

Tab. II Overview of the anatomical variables in the spatial relation between the mandibular canal and the mandibular third molar (in bold print = independent risk factors for postsurgical damage of the inferior alveolar nerve according to Eyrich et al. [Eyrich et al. 2011]).

	absolute frequency (n)	relative frequency (%)
direct contact of mandibular canal and root	559	46.7%
close proximity of mandibular canal and root	344	28.7%
measurable distance from mandibular canal to root	294	24.6%
apical course of mandibular canal	469	39.2%
buccal course of mandibular canal	347	29.0%
subcategory: mandibular canal runs buccally, compact bone preserved completely	329	27.5%
subcategory: mandibular canal runs buccally, mandibular canal runs through compact bone	18	1.5%
mandibular canal runs lingually	285	23.8%
subcategory: mandibular canal runs lingually, compact bone preserved completely	139	11.6%
subcategory: mandibular canal runs lingually, mandibular canal runs through compact bone	146	12.2%
interradicular course of the mandibular canal	89	7.4%
intraradicular course of the mandibular canal	7	0.6%
shape of the mandibular canal in the area of the wisdom tooth		
round cross section	402	33.6%
oval cross section	512	42.8%
flat cross section	283	23.6%

Tab. III Overview of the anatomical variables in the spatial relation between the mandibular canal and the mandibular third molar relative to number of roots and stage of development.

	absolute frequency (n)	relative frequency (%)
Tooth development		
fully matured roots	1004	83.9%
not fully matured roots	193	16.1%
Number of root tips		
tooth bud (not developed)	43	3.6%
1	255	21.3%
2	662	55.3%
3	211	17.6%
4	24	2.0%
5	2	0.2%

Tab. IV Overview of the anatomical variables in the spatial relation between the mandibular canal and the mandibular third molar, focusing on the lingual compact bone.

	absolute frequency (n)	relative frequency (%)
Lingual compact bone		
Intact	821	68.6%
Perforated	376	31.4%
Buccal compact bone		
Intact	1146	95.7%
Perforated	51	4.3%

Due to this high variability, the practitioner must consider all possible courses of the nerve until the 3D image can clarify the situation. The different relative distributions in the various studies (Maegawa et al. 2003; Mahasantipiya et al. 2005; Ohman et al. 2006; Tantanapornkul et al. 2009; Lubbers et al. 2011a) are, in the light of their qualitatively identical statement that high variability exists, of no real relevance for daily clinical routine.

In almost half the cases, there is direct contact between the mandibular canal and the root and close proximity in a quarter of the cases, which demonstrates that a 2D image can indeed predict a close relationship between the root of the mandibular third molar and the mandibular canal. Various other studies confirm this (Mahasantipiya et al. 2005; Ohman et al. 2006; Lubbers et al. 2011a). Earlier studies showed that direct contact at least is an independent factor for increasing the statistical likelihood of a (temporary) lesion of the inferior alveolar nerve after surgical tooth removal (Eyrich et al. 2011).

The same applies to a constriction of the nerve canal with a flat cross section in the area of contact with the tooth. This was found in almost a fourth of the cases (Eyrich et al. 2011). The fact that the cross sections of the canals can be divided into equally large groups of *round* and *oval* is less relevant. For one thing, a round mandibular canal cut on a slant appears oval, and for another, an oval shape indicates a less pronounced constriction in comparison to a flat cross section.

The distribution of the root configurations followed an expected pattern. A fifth of the teeth had more than two roots, which is hard to discern on a conventional orthopantomogram due to the superimposition (Engstrom & Sagne 1980).

The vast majority of the examined mandibular third molars appear to have a mesial or vertical type of angulation (Fig. 9). This disagrees with the findings of Tantanapornkul et al., who, in a smaller sample of 80 teeth, saw that 48% of the teeth were positioned horizontally (Tantanapornkul et al. 2009). However, it agrees with the findings of most other studies (Santamaria & Arteagoitia 1997; Kruger et al. 2001; Venta et al. 2001; Sedaghatfar et al. 2005; Almendros-Marques et al. 2006). However, the stage of radicular development and the type of impaction in the sagittal plane can easily be identified using conventional radiographs (Almendros-Marques et al. 2008). Hence, it is of no particular relevance for the indication and clinical use of CBT.

The angulation in the coronal plane (lingual-vestibular), however, is a different matter. In conventional imaging, this is not depicted sufficiently, because it is a slant vertical to the plane of the film. Most of the teeth in the present study were positioned along a vertical axis, and the lingual axis was the second most common variation. The scattering was much less in the coronal than in the sagittal plane (Fig. 9 and 10). Although neither the axes of the tooth nor the second molar used for reference are good for highly exact measurements, the statement about the type of impaction is valid, since there are not only definite results but also a large number of cases.

The high number of perforations of the lingual compact bone in a third of the cases agrees well with the frequently very close relationship between the tooth and lingual bone wall, which is often quite thin. Furthermore, the root tips of teeth that are less angulated in the coronal plane regularly run directly along or even through the lingual compact bone, due to the lingual undercut. Buccal perforations are rare and mainly occur when teeth are at a strong lingual slant. Neither type of perforation can be depicted on the conventional image. Especially lingual perforations, where the root tips are located beneath the lingual undercut in the floor of the mouth, bear a relevant risk of not being able to be removed safely, should there be a root fracture during tooth extraction. Removal from the floor of the mouth would then naturally be quite complicated (Lubbers et al. 2011c).

The retrospective character of this study, which cannot guarantee that no patient fulfilling the criteria of the study was overlooked, is a limitation. This limitation is, however, compensated by the high number of teeth that were examined. Therefore, the results can be considered as representative. A further weakness based on the retrospective character of the study is that the indication for three-dimensional imaging was not defined by any exact criteria. The decision-making process in daily clinical practice was basically controlled at two sites. The final decision was made by consulting a senior surgeon and following international recommendations. Nonetheless, natural deviations due to individual approaches were inevitable.

Current guidelines (Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde 2009; Sedentexct Project 2012) recommend

Tab. V Overview of the angulation of the tooth axes of the mandibular third molars in relation to the mandibular second molars on the sagittal and coronal planes.

	absolute frequency (n)	relative frequency (%)
Sagittal angulation of the third molar		
None	550	45.9%
Mesial	531	44.4%
Distal	116	9.7%
Coronal angulation of the third molar		
None	739	61.7%
Lingual	423	35.3%
Buccal	35	2.9%

Tab. VI Overview of the pathological findings in this area

	absolute frequency (n)	relative frequency (%)
unremarkable	849	70.9%
crown-root bend	22	1.8%
mandibular canal lies in a groove of the root	9	0.8%
pericoronal lesion	76	6.3%
apical lesion	25	2.1%
carious lesion	146	12.2%
resorption at the second molar	60	5.0%
incompletely operatively treated tooth	6	0.5%
miscellaneous: cystic lesion (1), osseous dysplasia (2), fractured mandible (2), periodontal lesion/deterioration (1), root remainders (1)	7	0.6%

that CBT imaging be used if the spatial relation between mandibular canal and mandibular third molar cannot be interpreted sufficiently on an orthopantomogram and is considered critical. It is also recommended should there be pathologies such as cystic lesions or resorption in adjacent teeth.

Based on the variety and frequency of variations in anatomy and positioning of mandibular third molars as demonstrated in this study and other literature (Maegawa et al. 2003; Mahasantipiya et al. 2005; Ohman et al. 2006; Tantanapornkul et al. 2009), it can be assumed that an exact presurgical clarification of the anatomy should reduce the rate of complications for the risks associated with this procedure. There are studies indicating that the use of 3D imaging does not influence the frequency with which postoperative damage to the nerve occurs (Guerrero et al. 2012; Suomalainen et al. 2012), yet their degree of evidence is low due to the number of cases and/or design of the study. Furthermore, they only focus on the possibility of a single complication (damage to the inferior alveolar nerve). Thus, the presumed advantages for the surgeon (and indirectly for the patient as well) are not refuted.

Further examinations should concentrate on whether or not preoperative 3D imaging of the mandibular wisdom teeth has a (positive) effect on the surgical morbidity and in which subcategories this is the case (Susarla & Dodson 2007; Friedland et al. 2008). The focus should not only be on the damage inflicted upon the inferior alveolar nerve. Unfortunately, a large number of cases are necessary due to the (fortunately) low rate of complications, thus making it technically difficult to bring about this verification. Therefore, one might have to be content with the level of evidence provided by consensus opinions, as is the case in many fields of medicine, especially in surgery.

The indications for using CBT should always be checked very carefully bearing radiation safety in mind. The ALARA principle, stating that the exposure to radiation should be "**A**s **L**ow **A**s **R**easonably **A**chievable", should be applied in 3D imaging just as it is in any other type of x-ray imaging. Consequently, the primary goal should be to avoid x-ray imaging. If needed, the second step would be the use of conventional radiographic techniques, such as radiographs of the tooth and orthopantomograms. Should this not suffice to clarify the situation, then a 3D image of the critical area, and only this area, can be made. On a dental level, which mainly concerns hard tissue, 3D imaging is generally essentially equivalent to CBT. This usually entails fewer effective doses than a classic Multi Detector Computer Tomogram (MDCT). Nevertheless, Ludlow et al. (2006) were able to show that individual devices performed just as well or even better than the MDCT. The device used in this study lies at the lower end of the spectrum of the examined CBTs (Ludlow & Ivanovic 2008) with 69 µSv (weighted according to IRCP 2007). The load is still about ten times higher than that of an orthopantomogram (Ludlow et al. 2006).

Thus, for clinical work, the rule applies to use step-wise (gradually increasing) radiological diagnostics, and to always reflect critically whether or not the next step is really necessary or if there is already enough information to provide a valid diagnosis and/or treatment. One would be well advised to avoid routine and unreflected use of CBT imaging, not only when dealing with wisdom tooth removal, but in general.

The amount of experience the surgeon has also influences the rate of complications (Bataineh 2001; Jerjes et al. 2006). Hence, it seems important to include experienced colleagues in the process of treatment and to refer especially complicated cases to specialists.

Résumé

L'extraction de dents de sagesses incluses est une des procédures chirurgicales les plus fréquentes. L'imagerie 3D est souvent utilisée et la nécessité de son usage intensément discutée. L'objectif de cette étude était de décrire les variations anatomiques de localisation des 3es molaires inférieures et d'éclaircir le besoin de recourir à l'imagerie 3D pour ces interventions.

Une étude rétrospective de cas de patients d'un département de chirurgie orale a été établie sur une période allant de janvier 2009 à février 2013. Les variables primaires de l'étude comprenaient la relation dans l'espace du canal mandibulaire, l'angulation et configuration des racines ainsi que le stade de croissance de la dent. Une statistique descriptive de toutes ces variables a été calculée.

1197 dents de sagesse ont été en tout évaluées chez 699 patients. Un contact direct avec le canal mandibulaire a été établi dans 46,7%, une proximité dans 28,7% et un écart mesurable dans 24,6% des cas. Par rapport à la dent, le canal mandibulaire si situait vestibulaire dans 29,0%, 23,8% lingual, 7,4% interradiculaire et 0,6% intraradiculaire. La plupart des dents avaient une (21,3%) ou deux (55,3%) racines. Le reste variait entre trois (17,6%), quatre (2,0%) ou cinq (0,2%) racines. Pour 31,4% des dents, les racines perforaient la corticale linguale et dans 4,3% la corticale vestibulaire. Une angulation mésiale de la dent se présentait dans 44,4% et distale dans 9,7%. Une version linguale dans 35,3% et vestibulaire dans 2,9%. Vu la diversité anatomique des 3es molaires inférieures, il est recommandé de faire une radio 3D avant l'extraction d'une dent de sagesse, étant donné qu'une radiographie conventionnelle n'a pas le pouvoir discriminatoire d'une position complexe.

References

Almendros-Marques N, Berini-Aytes L, Gay-Escoda C: Influence of lower third molar position on the incidence of preoperative complications. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 102: 725–732 (2006)

Almendros-Marques N, Berini-Aytes L, Gay-Escoda C: Evaluation of intraexaminer and interexaminer agreement on classifying lower third molars according to the systems of Pell and Gregory and of Winter. J Oral Maxillofac Surg 66: 893–899 (2008)

Baqain Z H, Karaky A A, Sawair F, Khraisat A, Duaibis R, Rajab L D: Frequency estimates and risk factors for postoperative morbidity after third molar removal: a prospective cohort study. J Oral Maxillofac Surg 66: 2276–2283 (2008)

Bataineh A B: Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg 59: 1012–1017; discussion 1017 (2001)

Blondeau F, Daniel N G: Extraction of impacted mandibular third molars: postoperative complications and their risk factors. J Can Dent Assoc 73: 325 (2007)

Cormack A M: Representation of a Function by Its Line Integrals, with Some Radiological Applications. J Appl Phys 34: 2722–2727 (1963)

Cormack A M: Representation of a Function by Its Line Integrals, with Some Radiological Applications. II. J Appl Phys 35: 2908–2913 (1964)

Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde: Dentale Volumentomographie (DVT) – S1-Empfehlung. German Dental Journal 64: 490–496 (2009)

Engelke W G, Diederichs C G, Deckwer, II: Preoperative imaging in a case of molar retention. Int J Oral Maxillofac Surg 26: 278–279 (1997)

Engstrom H, Sagne S: The anatomy of the lower-third-molar roots and its relation to the mandibular canal. Swed Dent J 4: 169–175 (1980)

Eyrich G, Seifert B, Matthews F, Matthiessen U, Heusser C K, Kruse A L, Obwegeser J A, Lubbers H T: 3-Dimensional imaging for lower third molars: is there an implication for surgical removal? J Oral Maxillofac Surg 69: 1867–1872 (2011)

Friedland B, Donoff B, Dodson T B: The use of 3-dimensional reconstructions to evaluate the anatomic relationship of the mandibular canal and impacted mandibular third molars. J Oral Maxillofac Surg 66: 1678–1685 (2008)

Guerrero M E, Nackaerts O, Beinsberger J, Horner K, Schoenaers J, Jacobs R: Inferior alveolar nerve sensory disturbance after impacted mandibular third molar evaluation using cone beam computed tomography and panoramic radiography: a pilot study. Journal of oral and maxillofacial surgery: official journal of the American Association of Oral and Maxillofacial Surgeons 70: 2264–2270 (2012)

Haug R H, Perrott D H, Gonzalez M L, Talwar R M: The American Association of Oral and Maxillofacial Surgeons Age-Related Third Molar Study. J Oral Maxillofac Surg 63: 1106–1114 (2005)

Hounsfield G N: Computerized transverse axial scanning (tomography). 1. Description of system. Br J Radiol 46: 1016–1022 (1973)

Jaquiery C, Pajarola G F, Sailer H F, Lambrecht J T: The extraction of retained mandibular wisdom teeth (I). The indications and preoperative diagnosis. Schweiz Monatsschr Zahnmed 104: 1510–1519 (1994)

Jerjes W, El-Maaytah M, Swinson B, Banu B, Upile T, D'sa S, Al-Khawalde M, Chaib B, Hopper C: Experience versus complication rate in third molar surgery. Head Face Med 2: 14 (2006)

Kruger E, Thomson W M, Konthasinghe P: Third molar outcomes from age 18 to 26: findings from a population-based New Zealand longitudinal study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 92: 150–155 (2001)

Lubbers H T, Kruse A L, Obwegeser J A, Gratz K W, Eyrich G: Oblique high resolution tomography: The ideal plane for visualization of the gonial section of the mandibular canal and its related structures? J Healthc Eng 3: 87–104 (2012)

Lubbers H T, Matthews F, Damerau G, Kruse A L, Obwegeser J A, Gratz K W, Eyrich G K: Anatomy of impacted lower third molars evaluated by computerized tomography: is there an indication for 3-dimensional imaging? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 111: 547–550 (2011a)

Lubbers H T, Matthews F, Damerau G, Kruse A L, Obwegeser J A, Gratz K W, Eyrich G K: No plane is the best one-the volume is! Oral Surg Oral Med Oral Pathol Oral Radiol Endod (2011b)

Lubbers H T, Obwegeser J A, Matthews F, Eyrich G, Gratz K W, Kruse A: A simple and flexible concept for computer-navigated surgery of the mandible. J Oral Maxillofac Surg 69: 924–930 (2011c)

Ludlow J B, Davies-Ludlow L E, Brooks S L, Howerton W B: Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dento maxillo facial radiology 35: 219–226 (2006)

Ludlow J B, Ivanovic M: Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 106: 106–114 (2008)

Maegawa H, Sano K, Kitagawa Y, Ogasawara T, Miyauchi K, Sekine J, Inokuchi T: Preoperative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 96: 639–646 (2003)

Mahasantipiya P M, Savage N W, Monsour P A, Wilson R J: Narrowing of the inferior dental canal in relation to the lower third molars. Dentomaxillofac Radiol 34: 154–163 (2005)

Nakagawa Y, Ishii H, Nomura Y, Watanabe N Y, Hoshiba D, Kobayashi K, Ishibashi K: Third molar position: reliability of panoramic radiography. J Oral Maxillofac Surg 65: 1303–1308 (2007)

Nakamori K, Fujiwara K, Miyazaki A, Tomihara K, Tsuji M, Nakai M, Michifuri Y, Suzuki R, Komai K, Shimanishi M, Hiratsuka H: 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: 2308–2313 (2008)

Ohman A, Kivijarvi K, Blomback U, Flygare L: Pre-operative radiographic evaluation of lower third molars with computed tomography. Dentomaxillofac Radiol 35: 30–35 (2006)

Rood J P, Shehab B A: The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 28: 20–25 (1990)

Santamaria J, Arteagoitia I: Radiologic variables of clinical significance in the extraction of impacted mandibular third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84: 469–473 (1997)

Sedaghatfar M, August M A, Dodson T B: Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. J Oral Maxillofac Surg 63: 3–7 (2005)

Sedentexct Project: Radiation Protection: Cone Beam CT for Dental and Maxillofacial Radiology. Evidence based guidelines. European Commission's Radiation Protection (2012)

Suomalainen A, Apajalahti S, Vehmas T, Venta I: Availability of CBCT and iatrogenic alveolar nerve injuries. Acta odontologica Scandinavica (2012)

Susarla S M, Dodson T B: Preoperative computed tomography imaging in the management of impacted mandibular third molars. J Oral Maxillofac Surg 65: 83–88 (2007)

Tantanapornkul W, Okochi K, Bhakdinaronk A, Ohbayashi N, Kurabayashi T: Correlation of darkening of impacted mandibular third molar root on digital panoramic images with cone beam computed tomography findings. Dentomaxillofac Radiol 38: 11–16 (2009)

Venta I, Turtola L, Ylipaavalniemi P: Radiographic follow-up of impacted third molars from age 20 to 32 years. Int J Oral Maxillofac Surg 30: 54–57 (2001)