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Patient-, software-, and observer-related factors associated with the time required for semi-automated measurements of the maxillary sinus volume using cone beam computed tomography (CBCT)

KEYWORDS
Cone beam computed tomography
Digital natives
Digital workflow
Maxillary sinus
Volumetric measurement

SUMMARY

This study aimed to evaluate patient-, software-, and observer-related factors influencing the time required for volumetric measurements of maxillary sinuses using cone beam computed tomography (CBCT) and a commercially available software. The volumes of healthy bilateral maxillary sinuses of adult patients from CBCT images taken during a 15-month study period were measured using dedicated software by two observers. The time required for volumetric assessments was evaluated statistically with respect to the potential influence of gender, age, sinus side, sinus volume, sequence of measurement, and selection threshold of the software. The resulting average sinus volume of the 174 sinuses from 87 patients was 16.9 cm^3. The average time required to measure one sinus volume was 91.8 s. Sinuses from male patients required a longer time (median of 95.5 s) for the measurements than their female counterparts (median of 87.5 s). Measurement time increased with increasing age, sinus volume and selection threshold based on calculated grey values provided by the software. The volumetric measurements and measurement times exhibited a high intra-observer agreement. The volumetric measurements were highly reproducible. Each measurement was completed within 4 minutes, though there was a marked difference in the mean measurement time between the two observers. Semi-automated volumetric measurement of the maxillary sinus with commercially available software is feasible, efficient, and reproducible. Based on these favourable findings, practitioners might consider using such volumetric instead of linear measurements to plan and analyse outcomes of sinus grafting procedures in daily clinical practice.

Introduction

Dental implant placement is a common and accepted surgical procedure to replace missing teeth. In the posterior maxilla, bone height and density are reduced when teeth have been missing over a prolonged time period (Pietrokovski & Massler 1967), and the maxillary sinus forms a natural anatomic barrier for standard implant insertion. To overcome these unfavourable conditions, sinus floor elevation (SFE) using a transcrestal or a lateral window approach is a widely used and predictable treatment option (Bornstein et al. 2008; Lundgren et al. 2017). During the planning of a SFE procedure, surgeons will need to evaluate the maxillary sinus anatomy regarding health and pathology, and also assess its volume, especially in the basal aspects (Bornstein et al. 2017; Yeung et al. 2018). From a clinician's point of view, such an assessment will enable the surgeon to ensure healthy conditions prior to an elective intervention, to assess the sinus morphology and space available for grafting materials, and to choose an appropriate surgical technique (Uchida et al. 1998).

The volumetric evaluation of air cavities such as the maxillary sinuses can be performed using a semi-automated digital workflow or through tedious manual measurements on slice-by-slice images. By adopting digitalization, one would expect a more reliable and time-efficient workflow. Indeed, previous studies have demonstrated the usage and accuracy of semi-automated software for volumetric measurements of the paranasal sinuses or the nasal airway with images from computed tomography (CT) scans (Alsufyani et al. 2016; Dastidar et al. 1999; Deeb et al. 2011). Whereas it has been demonstrated that the time required to measure such volumes can be reduced from 109 minutes to 49 minutes (Alsufyani et al. 2016), other studies have only suggested an increased time efficiency without reporting the actual time required for the volumetric measurements (Dastidar et al. 1999; Deeb et al. 2011). Furthermore, it has been reported that a digital workflow for single tooth implant-supported restorations and virtual planning of maxillofacial interventions can result in a significant reduction in time and cost of these treatments in daily practice (Joda & Brägger 2015a; Resnick et al. 2016). A recent study has reported that it took less than 4 minutes to analyse the volume of a maxillary sinus by using a customized software program and cone beam computed tomography (CBCT) data (Schriber et al. 2018). However, there has not yet been any evaluation on the actual time required for volumetric measurements of the maxillary sinus using a commercially widely available software.

The research question addressed in the current study was whether 3D volumetric analysis using a commercially available software for dental treatment planning was practical or not in terms of time required. Thus, the purpose of the present study was to determine the time to measure the volume of bilateral maxillary sinuses using CBCT scans with the help of a semi-automated, commercially available computer software. The second purpose was to evaluate the differences in the time needed by two observers experienced in oral and maxillofacial radiology. Secondary outcome variables included factors influencing the time needed for these analyses such as gender or size of the sinuses, and also the reproducibility of the measurements.

Materials and methods

Patient selection

All patients scheduled for CBCT imaging at Oral and Maxillofacial Radiology, Applied Oral Sciences, Faculty of Dentistry, The University of Hong Kong, were initially eligible for this study. The CBCT images were taken between 1 January 2016 and 31 March 2017. These radiographic data sets were retrospectively screened applying the following inclusion criteria: patients ≥18 years old, both maxillary sinuses entirely visible and healthy on the CBCT scan. The CBCT images were excluded if:

(1) One or both of the maxillary sinuses were not completely visible;
(2) Surgeries (ENT, maxillofacial) had been performed or the region of the maxillary sinuses had a history of trauma;
(3) The maxillary sinus regions were not free of artefacts (acquisition or patient-related);
(4) There was pathology from anterior teeth (canine-to-canine) impinging into one or both of the maxillary sinuses;
(5) There was pathological change in one or both of the maxillary sinuses. For instance, the Schneiderian membrane demonstrated uniform thickening of at least 4 mm, semispheric thickening, or mixed flat and semispherical thickenings; or the sinus(es) demonstrated a complete opacification, or other changes (e.g., bone destruction, cyst, aspergilloma, foreign body, suspected neoplasia) (Bornstein et al. 2012; Janner et al. 2011; Schneider et al. 2013; Soikkonen & Ainamo 1995).

The demographic data of the patients was collected from the respective medical histories to include gender and age (at the time of imaging). The study followed the guidelines of the Declaration of Helsinki. The study protocol was submitted to and approved by the local institutional review board (IRB) of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (approval number UW 16-495).

Imaging and evaluation procedure

CBCT scans were obtained using a ProMax 3D Mid (Planmeca Oy, Helsinki, Finland) machine, recorded at 90 kV and 5.6 mA using variable medium to large fields of view (FOV) (Bornstein et al. 2014) ranging from 8×8 cm to 20×17 cm (diameter × height). The data were reconstructed with slices at an interval of 0.5 mm, and either a 0.2- or 0.4-mm voxel size was used.

The CBCT images were displayed using a Lenovo ThinkCentre M91p workstation (Lenovo, Beijing, China) and a 22-inch Philips 223V LED monitor with a resolution of 1,920×1,080 pixels (Philips, Amsterdam, Netherlands). Image analysis was performed using a commercially available software (Planmeca Romexis Version 4.4.0.R, Planmeca Oy, Helsinki, Finland). Initially, the centre of the maxillary sinus was located manually in a multi-planar reconstruction (MPR) view (Fig. 1). Then, the maxillary sinus was selected with the "measure rectangle" tool. Within the air cavity of the respective maxillary sinus a voxel was chosen as the "seed" and the "region growing" tool was utilized to include all contiguous voxels that fell within a predefined voxel value. All voxels with simulated Hounsfield unit (HU) values below that of the seed and voxels with HU values higher than the seed up to the default threshold of 300 HU were initially included in the volume. This default threshold (300 HU) was adjusted for each sinus on an individual basis to include the largest number of voxels within the air cavity of the maxillary sinus but not of the surrounding structures. The volume calculated by the software was recorded for each sinus separately (in cm^3).

The time required to measure the volume of each maxillary sinus from each patient was noted down. Timekeeping started

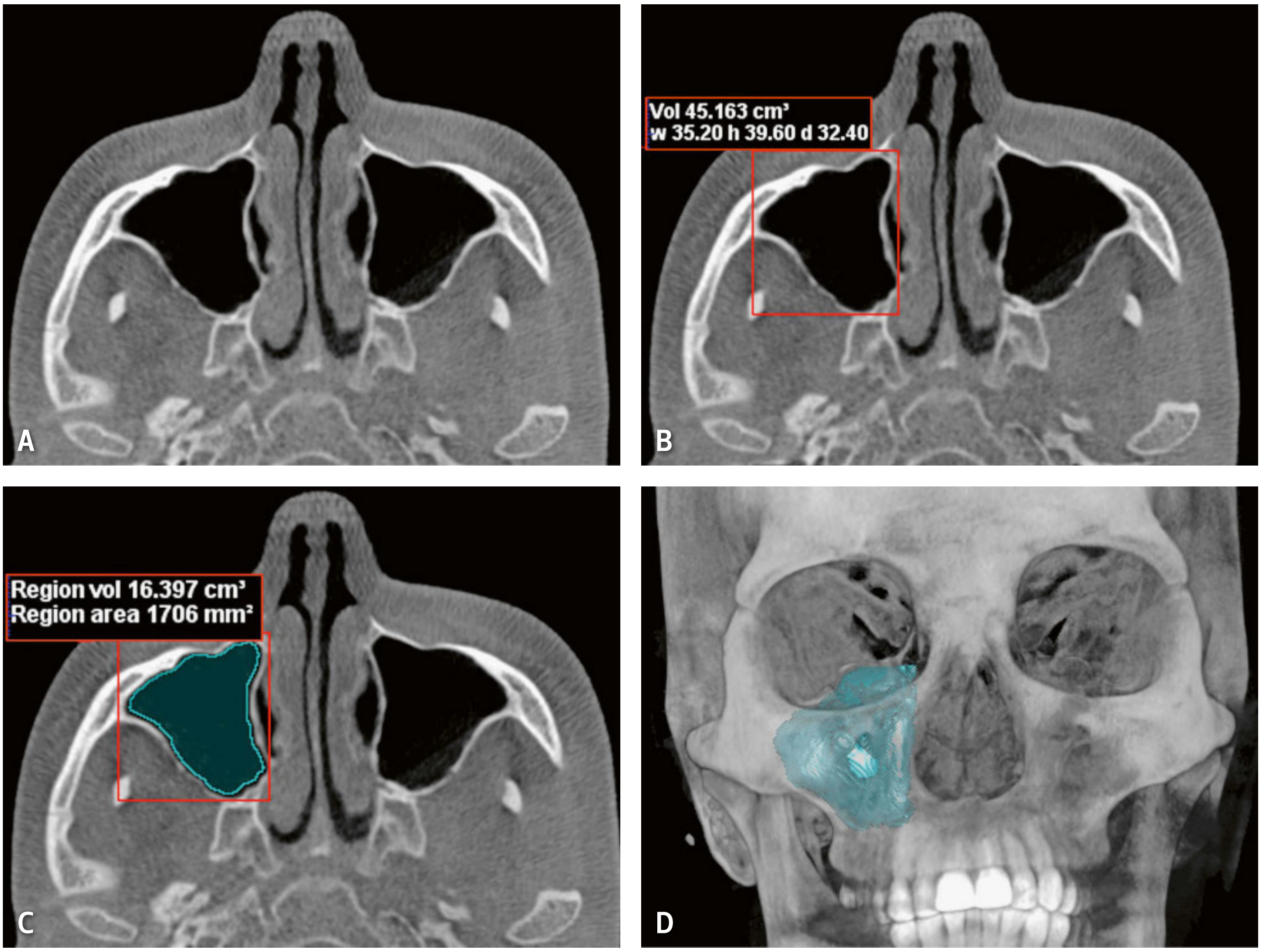

Fig. 1 Volumetric measurement of the right maxillary sinus of a representative 27-year-old female patient. (A) Manual centring of the maxillary sinus viewed on an axial slice; (B) manual selection of the right maxillary sinus with the "measure rectangle" tool; (C) volume determination of the right maxillary sinus ("Region vol") with "region growing" tool and manual adjustment of the appropriate voxel threshold in simulated Hounsfield units to maximize the number of voxels within the air cavity and minimize the number of voxels in the surrounding structures; (D) volume rendering of the maxillary sinus (turquoise) within the skull of the patient.

when the observer began to use the software to evaluate the sinus, and stopped when the final volume calculated by the software was obtained, including the time to set the threshold. The left sinus was measured first for the initial half of the patients included, whereas the right sinus was measured first for the latter half of the patients. Two observers, one dentist experienced in oral and maxillofacial radiology (AY) and a board-certified oral and maxillofacial radiologist (RT), performed all analyses independently after adequate training and calibration with the Romexis software. The measurements were performed once by each observer to test for inter-observer reliability (reproducibility). The first observer (AY) performed the measurements twice for 20 randomly selected patients (www.randomizer.org) to test for intra-observer reliability (repeatability). For further data analysis, the first readings from AY and the readings from RT were independently utilized.

Statistical analysis

All data were first analysed using descriptive statistics. Age was divided by a median split yielding two age groups for further statistical analysis.

The effects of the binary independent variables (gender, age, sinus side and sequence of measurement) on the time required for the volumetric measurements were separately evaluated with a two-sample t-test. The effects of continuous independent variables (sinus volume and selection threshold) were evaluated with a Spearman's correlation test. Intra-observer variability (repeatability) and inter-observer agreement (reproducibility) for sinus volume values, measurement time and selection threshold were assessed using interclass correlation (ICC) coefficients. Moreover, the effect of the individual observer on the measurement time and selection threshold chosen was separately tested by a two-sample t-test. Meanwhile, the effects of age and gender in relation to sinus volume (pooled mean data for both observers) were separately tested by a two-sample t-test.

The significance level chosen for all statistical tests was $p \leq 0.05$. Statistical procedures were carried out in SPSS (version 24.0, IBM, NY, USA).

Results

Population and image analysis details

A total of 537 CBCT scans were preliminarily screened. The initial screening process excluded 383 CBCT scans, as they did not exhibit complete visualization of bilateral maxillary sinuses. A further 67 CBCT scans were excluded as they did not

Tab. I Demographic data and measurement outcomes of the patients analysed

	Mean/Median	Standard deviation	Minimum/Maximum value
Age (year)	29.6/24.3	13.4	18.0/82.0
Sinus volume (cm^3)	16.9/16.6	6.3	3.9/34.0
Selection threshold (HU)	404.8/404.5	48.0	282.0/577.0
Measurement time (sec)	91.8/89.5	19.5	57.0/166.0

Data averaged from both observers (AY and RT) are listed here for sinus volume, selection threshold and measurement time.

Tab. II Time required for the volumetric measurements of the maxillary sinuses grouped into the different parameters

Gender	Sample size (% of sample)	Mean/Median time (sec)	Standard deviation (sec)	Minimum/Maximum value (sec)
Male	54 (31.0%)	96.9/95.5	18.4	67.5/135.5
Female	120 (69.0%)	89.5/87.5	19.7	57.0/166.0
Age group	**Sample size (%)**	**Mean/Median time (sec)**	**Standard deviation (sec)**	**Minimum/Maximum value (sec)**
18.0–24.3	88 (50.6%)	88.4/86.8	16.7	57.0/135.0
24.4–82.0	86 (49.4%)	95.3/93.0	21.6	59.5/166.0
Sinus side	**Sample size (%)**	**Mean/Median time (sec)**	**Standard deviation (sec)**	**Minimum/Maximum value (sec)**
Left	87 (50.0%)	92.6/90.5	18.9	60.5/155.0
Right	87 (50.0%)	91.0/89.5	20.3	57.0/166.0
Sequence of measurement	**Sample size (%)**	**Mean/Median time (sec)**	**Standard deviation (sec)**	**Minimum/Maximum value (sec)**
First	87 (50.0%)	93.1/92.0	19.8	57.0/155.0
Second	87 (50.0%)	90.5/86.5	19.4	60.5/166.0

Data averaged from both observers are listed.

exhibit healthy bilateral maxillary sinuses. Therefore, the final study sample consisted of 87 CBCT scans (a total of 174 healthy maxillary sinuses). The FOVs included in the present study were 10 × 6 cm, 8 × 8 cm, 10 × 10 cm, 20 × 6 cm, 20 × 10 cm, and 20 × 17 cm. These CBCT scans varying from medium to large FOVs (Bornstein et al. 2014) were mostly indicated by oral and maxillofacial surgeons prior to orthognathic surgery, and also for implant treatment planning in the maxilla with or without SFE. There were 27 males and 60 females (31% and 69%, respectively) aged between 18 and 82 years with a mean of 29.6 years (Tab. I). Using the data averaged from both observers (AY and RT), the threshold range for the volumetric analysis was determined to be between 282 to 577 HU, and the resulting average sinus volume was 16.9 cm^3 (Tab. I). The average time required to measure sinus volume was 91.8 s with a median of 89.5 s.

Influence of factors on time required to measure maxillary sinus volumes

Data averaged from both observers showed that the mean time needed to measure one maxillary sinus in a male patient (96.9 s) was significantly longer than that needed to measure a female (89.5 s, Tab. II and III). The mean time needed to measure one sinus in the older age group 24.4–82.0 (95.3 s) was significantly longer than that in the younger age group 18.0–24.3 (88.4 s, Tab. II and III). Moreover, the time needed to measure a maxillary sinus was positively correlated to selection threshold (Tab. III). Meanwhile, the averaged data showed that there was no significant difference in the mean time needed to measure one maxillary sinus whether it was measured first (93.1 s) or second (90.5 s).

Effects of age and gender in relation to sinus volume

Data averaged from both observers showed that maxillary sinuses of patients below the median age of 24.3 (18.2 cm^3) were significantly larger than those of patients above 24.3 years (15.6 cm^3, $P = 0.005$). Maxillary sinuses of males (19.9 cm^3) were significantly larger than those of females (15.6 cm^3, $P < 0.001$) (Figs. 2 and 3).

Intra- and inter-observer variability

Intra-observer repeatability exhibited almost perfect agreement for the volume measurements of the maxillary sinuses, time needed for the measurements and selection threshold chosen for the measurements, with ICC coefficient values of 0.997, 0.944, and 0.895, respectively (all $P < 0.001$).

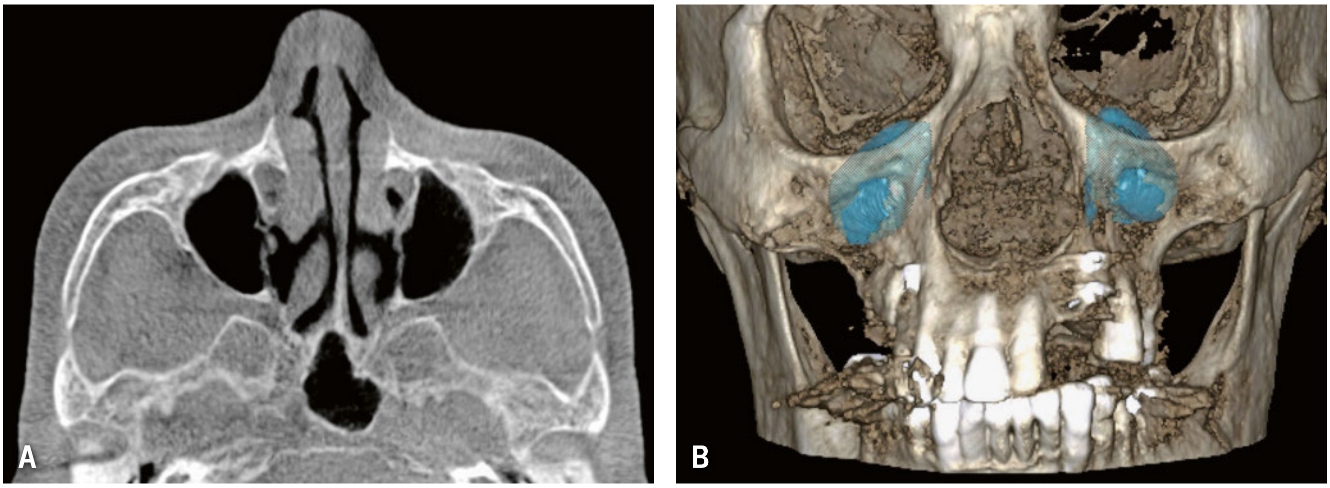

Fig. 2 Volumetric measurement of a small (3.9 cm^3, value averaged from both observers) left maxillary sinus of a 55-year-old female patient. (A) Sinus visualization in an axial slice; (B) volume rendering (turquoise) within the skull of the patient.

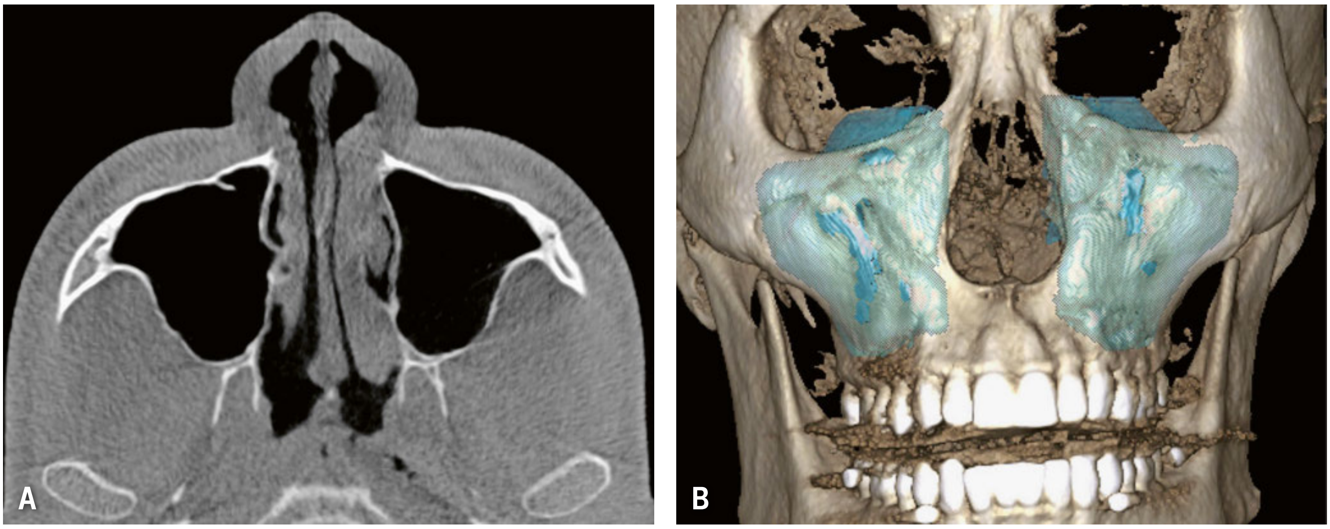

Fig. 3 Volumetric measurement of a large (34.0 cm^3, value averaged from both observers) right maxillary sinus of a 25-year-old male patient imaged using CBCT. (A) Sinus visualization in an axial slice; (B) volume rendering (turquoise) within the skull of the patient.

Inter-observer reproducibility exhibited almost perfect agreement for the volume measurements of the maxillary sinuses with an ICC coefficient value of 0.994 ($P < 0.001$, Tab. IV) for the two observers. For the time needed to measure the maxillary sinuses, a poor agreement of the values was found with an ICC coefficient of 0.385 ($P = 0.001$). Furthermore, the selection threshold chosen to measure the sinus volumes exhibited a significant difference when comparing both observers ($P = 0.015$). The average measurement time of one observer (AY, 82.4 s) was significantly shorter than for the second one (RT, 101.2 s, $P < 0.001$).

Discussion

The current study has revealed that the time needed to measure the volume of one maxillary sinus with the aid of a commercially available computer software was relatively short with approximately 1.5 minutes, which is comparable to the time required for similar measurements in a recent investigation using a customized software (Schriber et al. 2018). Overall, every measurement has taken less than 4 minutes to complete. These findings demonstrate that the procedure was efficient for both observers, whether they are termed as a "digital native" or a so-called "digital immigrant" (van der Zande et al. 2015). An important limitation of the present study was that the commercially available software used for the 3D volume analyses was not compared to another software, thus limiting the outcomes to one product.

Implementation and development of dedicated computer software has been a vital part in the recent success and hype surrounding digital dentistry, which includes fields ranging from computer-aided design/computer-aided manufacturing (CAD/CAM) of dental restorations (Ender & Mehl 2013) to more surgical indications such as virtual planning of orthognathic interventions (Swennen et al. 2009) or evaluation of potential sites for implant insertion (Bornstein et al. 2016, 2017). To plan for an implant crown, previous studies have reported that a digital impression required three minutes less than conventional impression taking with polyether, and reduced the cost by 18% (Joda & Brägger 2015a, 2015b). A straightforward implant treatment planning based on an analysis of available bone and selection of appropriate implant dimensions is actually possible by digital means using CBCT images and intraoral scans, but data on the time required is still scarce or missing (Bornstein et al. 2017).

Tab. III Analysis of potential influencing parameters on the time required for volumetric measurement of the maxillary sinus

Influencing parameters on sinus volume	Statistical test performed	P value (AY data)	P value (RT data)	P value (averaged data)
Gender	Two-sample t-test	**0.031**	0.069	**0.021**
Sinus side	Two-sample t-test	0.098	0.923	0.589
Age group	Two-sample t-test	0.903	**0.005**	**0.019**
Sequence of measurement	Two-sample t-test	0.274	0.555	0.372
Sinus volume	Spearman's correlation test	**0.021**	0.253	0.891
Selection threshold	Spearman's correlation test	**0.005**	0.532	**0.022**

Bold = statistically significant difference ($P < 0.05$)

Tab. IV Analysis of inter-observer agreement

Influencing parameters on measurement time	Mean (SD)		Intra-class coefficient (ICC)
	AY data	RT data	
Measurement time (sec)	82.4 (14.7)	101.2 (31.9)	0.385
Sinus volume (cm^3)	16.6 (6.2)	17.2 (6.4)	0.994
Selection threshold (HU)	371.0 (63.3)	438.5 (62.5)	0.282

Classification of ICC values: less than 0.400: poor; 0.400–0.599: fair; 0.600–0.749: good; 0.750 or above: excellent

In the current study, the maxillary sinus served as a straightforward and reproducible model for 3D analyses using a commercially available software, and also for analysing the required time and differences of this time between clinicians. After proving the practicality of these analyses using a sinus model, such 3D analyses could also be applied to evaluate entities such as jaw pathologies (Suter et al. 2015), and jaw regions to be grafted prior to or after augmentation in three dimensions. For example, the software Mimics (Materialise, Leuven, Belgium) was used to analyse volumetric changes of grafted bone in the maxillary sinus (Mazzocco et al. 2014), but the information about the time required for such analysis was lacking in the study. Therefore, the current investigation also assessed the potential obstacles of implementing such analyses in daily practice in terms of time required. As the time required to perform the analyses was relatively short, it seems to be a feasible option for various indications in the process of treatment planning.

A SFE is often indicated prior to implant insertion in the atrophic posterior maxilla, and CBCT images enable clinicians to plan for the graft and evaluate its potential outcome (Kim et al. 2013). The accuracy of sinus volume measurements by computer software has been evaluated (Bui et al. 2015), but the current investigation was the first to evaluate the time requirements for such analyses using a commercially available software designed for dental CBCT. The 1–2 minutes needed for a maxillary sinus volume analysis can certainly be spared in routine daily practice, and the indications for this software tool are certainly not limited only to SFE. They might be applied to other oral and/or maxillofacial surgical procedures such as horizontal or vertical ridge augmentations. Nevertheless, as the current investigation has to be seen more as a feasibility study, the implementation of such a software for specific indications in dental medicine and more specifically in implant dentistry has to be evaluated in more detail in future clinical studies.

The findings of the present study show that gender was an influencing factor for the time needed for the volume analyses. The analysis showed that sinuses of males required a longer time to be measured than their female counterparts. Moreover, data averaged from both observers have shown that males had significantly larger sinuses than females, so that the gender effect might be related to size of the sinus volume. This is consistent with previous studies that reported sinus volumes being larger in males compared to females (Schriber et al. 2018; Teke et al. 2007).

Age was another factor influencing the time needed for sinus volume measurements. The present study showed that it took longer to measure one maxillary sinus from the older than one from the younger age group. As results exhibited that the older age group had smaller maxillary sinuses than the younger age group, sinus size could not explain the longer measurement time required for the older age group. Thus, the reasons for this outcome are not clearly understood at the moment, and this association has to be interpreted with caution. However, one factor could be that generally younger adults were included in the current sample, as demonstrated by the median split of 24.3 years of age. Only 10 out of the 87 patients included in the current study were older than 50 years.

Selection threshold was found to be an influencing factor for the data from one observer (AY), and from data averaged from both observers. Precisely, the measurement time was longer, if the selection threshold was higher compared to the default setting. This could be expected as the sinuses with a higher threshold often exhibit difficulties of delineating their margins, and therefore require more time for fine-tuning. This fine-tuning could be seen in some cases, where voxels at the centre or the periphery of the maxillary sinus air space were not included for the volume calculation by the software, and only careful adjustment of the threshold enabled a better outcome.

Regarding the reproducibility of the measurements, the volumetric measurements from both observers were very similar, which is also demonstrated by the high ICC values. However, the average time needed for the measurements differed significantly between the observers. The analysis also revealed that the measurement time of one observer (AY), who was considerably younger than the other observer (RT), was significantly shorter (82.4 versus 101.2 s). Interestingly, the observer with the longer experience in oral and maxillofacial radiology needed more time for the analyses. Thus, although experience is an important factor for diagnostic imaging (Manning et al. 2006), it seems to have less or even no impact, when performing volume analyses. Here, familiarity and ease in the usage of modern digital technology appears to be of more importance regarding efficiency. Similarly, it has been reported that younger dentists – so-called "digital natives" – are more familiar with and skilled at using current digital technologies when compared to their elder colleagues in daily dental practice (van der Zande et al. 2015). A previous study has reported significant differences in three-dimensional orthodontic measurements between multiple observers using a computer software, and suggested that if the observers were "digital natives" the inter-observer reproducibility would be much better (Fabels & Nijkamp 2014). Furthermore, dental education in recent years has included teaching of the digital workflow, which might further explain the younger observer being more efficient (van der Zande et al. 2015).

Past studies on surgical planning or maxillary sinus anatomy focused mainly on linear measurements, but not actual analyses of three-dimensional volumes (Sahlstrand-Johnson et al. 2011; Stimmelmayr et al. 2017; Varghese et al. 2010). However, volume measurements before and after bone grafting procedures are clinically important as they might influence the selection of implant type and the mode of insertion (Kim et al. 2013). This could be of interest to study in more detail using software programmes with the potential of volume analyses similar to the one used in the present study. The maxillary sinus was chosen in the current study for volume analyses as a general and somewhat standardized model for such evaluations, and as a convenience sample to proof the feasibility. As younger dentists, the "digital natives", are relatively more adapted to and also willing to apply a digital workflow (van der Zande et al. 2015), it could be expected that more and more dentists will be using computer software for volume analyses in implant dentistry in the future.

Conclusion

Based on the findings of the present study, the following conclusions can be drawn:

- The average time needed for volume analysis of a maxillary sinus was 1.5 minutes.
- Measurement time of maxillary sinus volume was generally longer for male patients, and also for patients above the median age of 24.3 years.
- Volumetric measurements were highly reproducible, but with a significant difference in the average time needed for these measurements between the observers (82.4 versus 101.2 s).
- The maxillary sinus served as a readily available model for 3D analyses using a commercially available software, and also for analysing the required time and differences of this time between clinicians. The current study has shown that the workflow for such 3D analysis using a commercially available software is feasible, time-efficient, and highly reproducible, and may be considered for other conditions such as jaw pathologies, or prior to/after augmentative procedures.
- Future research to identify obstacles to implementing a digital workflow in daily practice seems warranted especially with a focus on differences between "digital natives" versus "digital immigrants".

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Zusammenfassung

Einführung und Ziel der Arbeit

Volumenmessungen von luftgefüllten Hohlräumen wie der Kieferhöhle können digital mithilfe von Computerprogrammen oder in Handarbeit über Messungen von Bild-zu-Bild durchgeführt werden. Die vorliegende Studie untersuchte patienten-, software- und beobachterbezogene Einflussfaktoren auf die Messzeit von Kieferhöhlenvolumina, die mithilfe der digitalen Volumentomografie (DVT) und eines kommerziell erhältlichen Computerprogramms berechnet wurden.

Material und Methoden

Zwei Beobachter berechneten die Volumina von bilateralen, ganz abgebildeten Kieferhöhlen mithilfe von DVT-Aufnahmen, die über einen Zeitraum von 15 Monaten hergestellt worden waren. Als Software zur Volumenberechnung wurde ein kommerziell erhältliches Programm verwendet (Planmeca Romexis Version 4.4.0.R, Planmeca Oy, Helsinki, Finnland). Die DVT-Aufnahmen wurden mit dem ProMax 3D Mid (Planmeca Oy, Helsinki, Finnland) und folgenden Einstellungen hergestellt: 90 kV und 5,6 mA mit einem mittleren bis grossen Volumen («field of view», FOV) von 8 × 8 cm bis 20 × 17 cm (Durchmesser × Höhe). Die Zeitdauer für jede Messung wurde erfasst, wobei diese von Beginn der Volumenanalyse durch den Beobachter bis zur abschliessenden Berechnung des Volumens durch das Computerprogramm reichte. Die errechnete Dauer der Volumenanalyse wurde dann auf Einflussfaktoren wie Geschlecht, Alter, Kieferhöhlenseite, Kieferhöhlenvolumen, Messsequenz und auch den eingestellten Grauwertebereich untersucht.

Resultate

Zu Beginn wurden 537 DVT-Aufnahmen untersucht, wovon dann 87 mit 174 bilateral abgebildeten, gesunden Kieferhöhlen in die Studie eingeschlossen wurden. Das durchschnittliche Volumen dieser Kieferhöhlen betrug 16,9 cm^3. Die durchschnittliche Zeitdauer für eine Volumenanalyse war 91,8 Sekunden, wobei es bei Männern (median von 95,5 s) länger dauerte als bei Frauen (87,5 s). Zudem brauchte es bei zunehmendem Alter, grösseren Volumina und zunehmendem Grauwertebereich mehr Zeit für die Volumenberechnung. Für den Vergleich der Zeiten beim gleichen Beobachter waren hohe Korrelationswerte vorhanden. Zudem waren die berechneten Volumina der beiden Beobachter vergleichbar. Keine Messung brauchte mehr als 4 Minuten, aber es war ein signifikanter Unterschied in der Messdauer zwischen den beiden Beobachtern vorhanden.

Diskussion und Schlussfolgerungen

Der Einsatz einer kommerziell erhältlichen Software zur Volumenberechnung von Kieferhöhlen scheint einfach und effizient zu sein sowie reproduzierbare Werte zu liefern. Aufgrund dieser positiven Resultate könnten solche volumetrischen Messungen anstelle von linearen Analysen für die Planung vor und auch die Analyse von Resultaten nach Kieferhöhlenbodenaugmentationen oder ähnlichen Eingriffen in der täglichen Praxis eingesetzt werden.

Résumé

Introduction et but

L'évaluation volumétrique des cavités d'air comme les sinus maxillaires se fait en utilisant un déroulement d'opérations numérique semi-automatisé ou avec des mesures manuelles sur des images de tranche-par-tranche. Cette étude vise à évaluer les facteurs de patient, de logiciel, et d'observateur influençant le temps requis pour des mesures volumétriques des sinus maxillaires utilisant la tomographie volumique par faisceau conique (TVPC) et un logiciel disponible sur le marché.

Matériels et méthodes

Des images de TVPC prises au cours d'une période d'étude de 15 mois sur les volumes de sinus maxillaires bilatéraux sains de patients adultes ont été mesurées par deux observateurs. Les images ont été analysées en utilisant un logiciel disponible dans le commerce (version 4.4.0.R, Planmeca Oy, Helsinki, Finlande). Des balayages de TVPC ont été obtenus en utilisant une machine de ProMax 3D (Planmeca Oy, Helsinki, Finlande), enregistrée à 90 kilovolts et à 5,6 mA utilisant des champs de vision moyens et élevés s'étendant du 8 × 8 cm au 20 × 17 cm (taille × diamètre). Le temps requis pour mesurer le volume de chaque sinus maxillaire de chaque patient a été noté. Le chronométrage a commencé au moment de l'utilisation du logiciel pour évaluer le sinus, et s'est arrêté quand le volume final calculé par le logiciel a été obtenu, et le temps de fixer le seuil du logiciel a été inclus. Le temps requis pour les évaluations volumétriques a été évalué statistiquement sous l'influence potentielle du sexe, de l'âge, du côté sinusal, du volume sinusal, de la séquence de mesure et du seuil de sélection du logiciel.

Résultats

Un total de 537 balayages de TVPC ont été préalablement examinés. L'échantillon final d'étude s'est composé de 87 balayages de TVPC (un total de 174 sinus maxillaires sains) avec un volume moyen en résultant de sinus de 16,9 cm^3. Le temps moyen requis pour mesurer un volume de sinus était 91,8 s. Les balayages des patients masculins ont exigé plus de temps (médiane de 95,5 s), ceux des femmes par contre moins (médiane de 87,5 s). Le temps de mesure a augmenté avec l'âge, le volume de sinus et le seuil de sélection basés sur des valeurs grises calculées par le logiciel. Les mesures et les temps volumétriques ont montré un accord élevé d'intraobservateur. Les mesures volumétriques étaient hautement reproductibles. Chaque mesure a été accomplie en moins de quatre minutes, mais il y a eu une différence remarquable dans le temps moyen de mesure entre les deux observateurs.

Discussion et conclusions

La mesure volumétrique semi-automatisée du sinus maxillaire avec le logiciel disponible dans le commerce est faisable, efficace et reproductible. Les praticiens pourraient donc envisager d'utiliser des mesures volumétriques (plutôt que des mesures linéaires) par exemple pour prévoir et analyser des résultats de procédures de greffes de sinus dans la pratique clinique quotidienne.

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