ORIGINAL ARTICLE

The Reliability of SketchAndCalc™ Area Calculator Software in Evaluating The Obturated Surface Area of Mandibular Premolars and Molars

Mustaffa M[a], Mat Yasin NM[b], Imam Sopingi SH[b], Mohd Ibrahim MS[c]

[a]Department of Restorative Dentistry, Kulliyyah of Dentistry, International Islamic University Malaysia, Pahang, Malaysia
[b]Undergraduate Dental Students, Kulliyyah of Dentistry, International Islamic University Malaysia, Pahang, Malaysia
[c]Department of Dental Public Health, Kulliyyah of Dentistry, International Islamic University Malaysia, Pahang, Malaysia

ABSTRACT

INTRODUCTION: The measurement consistency of an assessment tool in biomedical research is important for validation of data. This study aims to determine the reliability of SketchAndCalc™ Area Calculator software in evaluating the obturated surface area of single rooted mandibular premolars and mandibular first molars between two examiners and to compare with the previous studies. **MATERIALS AND METHODS:** 30 scanning electron microscopy (SEM) images of extracted single rooted mandibular premolars and 30 SEM images of mandibular first molars were obtained from the previous studies. The extracted teeth were previously obturated with GuttaFlow Bioseal. Calibration between two examiners was done prior to start of the study. SketchAndCalc™ Area Calculator software was used to evaluate the volumetric percentage of obturated surface area. Inter-examiner reliability was determined between two examiners and compared to the previous studies using Intraclass Correlation Coefficient (ICC) with the following categories; ICC<0.50: poor reliability, ICC 0.50-0.75: moderate reliability, ICC 0.75-0.90: good reliability, ICC>0.9: excellent reliability. The data was analysed with SPSS version 25.0. **RESULTS:** The ICC values between two examiners were 0.979 in mandibular premolars and 0.918 in mandibular molars. Meanwhile, the ICC values between two examiners and to the previous studies were 0.844 in mandibular premolars and 0.962 in mandibular molars. **CONCLUSIONS:** Excellent inter-examiner reliability was observed in premolars and molars, however when compared to the previous studies, good and excellent inter-examiner reliability were observed in premolars and molars respectively.

Keywords
SketchAndCalcTM Area Calculator software, mandibular premolars, mandibular molars, GuttaFlow Bioseal, Inter-examiner reliability.

Corresponding Author
Dr. Musliana Mustaffa
Department of Restorative Dentistry,
Kulliyyah of Dentistry,
International Islamic University Malaysia,
Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan,
Pahang, Malaysia.
E-mail: muslianamustaffa@iium.edu.my

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INTRODUCTION

Reliability is a measure of the stability or consistency of test scores and the ability for a test or research findings to be repeatable each time it is used. There are four types of reliabilities highlighted in literature such as test-retest, inter-rater, internal consistency, or intra-rater[1] and parallel forms.[2] Test-retest reliability manifests the variation in measurement taken by an instrument on the same subject under same conditions.[1] This test was done twice over a period to evaluate the stability of measurement provided by the instrument over the time. Parallel forms reliability measures the variation between different version of assessment tools on the same subjects under same conditions.[3] This was done to evaluate consistency of results across different versions of instruments. Inter-rater reliability reflects the variation between two or more raters who assess the same subjects.[1] Internal consistency or intra-rater reliability shows the variation of data measured by one rater in two or more trials.[1] In the endodontic field, the use of software in evaluating the obturated surface area comprising the obturation materials, voids and marginal gaps is a common practice and the ones that have been reported in the previous studies include; Image J software.[4-15] This software program is developed at the National Institute of Health and the Laboratory for Optical and Computational Instrumentation, University of Wisconsin, as an open source software with a simple user interface with various functions, designed for scientific multidimensional images, can perform various tasks, can

be downloaded from the ImageJ Download page.[16] It is usually used when evaluating the obturated surface area using the SEM/CLSM methods. Skyscan CT-Analyser (CTAn) software[17-24] can evaluate the voids and marginal gap, however when evaluating the obturation quality, it is usually done using additional software which is the Skyscan CT-Volume (CTVol) software.[17,21,22] Micro CT scanners are equipped with advanced micro CT analysis software including CTAn for 2D and 3D quantitative analysis of the reconstructed volumes from Micro CT scans, and CTVol for realistic 3D visualisation of scanned objects. The micro CT analysis can calculate various parameters such as bone volume fractions, materials volumes, structure and trabecular thickness, porosity, or particle analysis.

The data conversion using CTAn allows 3D assessment, which can be used to gain quantitative data.[22] NRecon software is commonly used together with CTAn for analyzing the image from micro-CT. NRecon software serves in reconstruction of images from micro-CT to two-dimensional (2D) cross-sectional slices of root canal.[25] Following reconstruction, the root canal surface area and volume will be calculated in unit mm^2 and mm^3.

Apart from the aforementioned software, Architecture software (ArchiCAD 8.0; Graphisoft, Munich, Germany),[26] Custom-written software,[27] 2008 AutoCAD software (version 1, serial number: 653-12354321),[28] Nis Elements software,[29] OnDemand3D software,[30] Volume-measurement software (i-View Image Center, Kitasenju Radist Dental Clinic, Tokyo, Japan),[31] Cell^D software (Olympus Soft Imaging Solutions GmbH, Münster, Germany),[32] NIH (National Institutes of Health) version 1.61 image analysis software,[33] AxioVision Rel. 4.8 software (Zeiss, Göttingen, Germany),[34] Image Tool software (UTHSCSA software, University of Health Sciences San Antonio, Texas),[35] SketchAndCalc™ Area Calculator Software.[36,37] The similarity of these software is the ability to measure the obturated surface area regardless of its operation. In general, the selection of the software to evaluate the obturated surface are is dependent on its availability, trained staff for its operation and cost for the license. Due to the lack of standardization in this aspect, general application into clinical situation is difficult to make, therefore it requires further investigation so that cumulatively, the existing reports on the appropriate software could help to achieve robust scientific findings. The goal of obturation is to provide a complete seal along the root canal, thus restricting the exposure of periapical tissue fluids and microorganism to the root canal system. Some factors that contribute to obturation quality include; obturation technique, obturation material, complexity of root canal anatomy and skills of clinicians. To assess the adaptation of obturation materials, voids and marginal gap in the root canal, several methods are available including stereomicroscopy, scanning electron microscopy (SEM), Miro-computed tomography (Micro-CT), Confocal Laser Scanning Microscopy (CLSM) and Cone-beam computed tomography (CBCT).

Each of these methods measures obturation quality through its specific features and higher resolution images, thus it would yield better assessment of the root canal treatment. To date, there is insufficient evidence to suggest which method is superior with regards to the ability to assess the obturated surface area accurately because each method has its own advantages and disadvantages. However, a combination method has been conducted such as radiograph and stereomicroscopy,[6,26] fluid filtration and SEM,[38] Micro CT and stereomicroscopy,[21,39] Micro CT and Nano CT,[19] Bacterial leakage model and Micro CT,[22] Stereomicroscopy and CLSM[14] and Micro CT and SEM.[17,20] Although a combination method could to help validate the findings, it requires more costs and more time-consuming procedure.

These might explain the use of only one method in a lot of reported studies. SketchAndCalc™ Area Calculator software is an application that is user-friendly, can be downloaded from electronic devices such as smartphone, tablets desktop or laptop, containing a set of instructions/ programs to execute specific tasks. It can calculate various areas of the uploaded images and has universal utility across many industries, gardeners, building contractors, surveyors, or home improvement. However, the use in education, medical field, science, and research fields is still limited, owing to the availability of other sophisticated software that can execute the tasks effectively. Despite that, recent studies in orthodontics, endodontics and

science field have utilised this software in their research such as quantifying the movement of cell upon wound healing using three different tools that include this software,[40] measurement on digital lateral cephalometric films on skeletal Class II malocclusion patients[41] and obturated surface area of root canal treated teeth.[36,37] It is proven that SketchAndCalc™ is possible to be applied in educational and biomedical research, yet further investigation is needed to determine whether this software is also applicable to another field of research, not restricted to a certain field but also to a broader area. This study aims to assess the reliability of SketchAndCalc™ Area calculator software in evaluating the obturated surface area in the extracted single rooted mandibular premolars and mandibular first molars between two examiners and to compare the findings with the previous studies involving the same teeth.

MATERIALS AND METHODS

This study received ethical approvals from the IIUM Research Ethics Committee (IREC); IREC 2018-029, IREC 2019-021.

SEM Images Selection

30 SEM images were obtained from previous study involving the extracted single rooted mandibular premolars[36] and another 30 SEM images involving the extracted mandibular first molars with moderate to severe root canal curvatures.[37] The images were carefully viewed to distinguish the outline of root canal wall, obturation materials, marginal gaps and voids within the obturation materials.

Calibration

A training session was conducted involving two examiners, an endodontist, and a trained staff. The two examiners had a limited experience in endodontology and had no experience in using the SketchAndCalc™ Area calculator software. The endodontist has 7 years of experience in endodontology and the trained staff have 3 years of experience in using the aforementioned software. Demonstration on how to sketch the SEM images using SketchAndCalc™ Area Calculator software was conducted by a trained staff who was involved with the software in the previous studies.[36,37] After the demonstration, the examiners started to sketch the SEM images under supervision of an endodontist. The process took place until the examiners were competent to self-sketch and could comprehend the use of each feature in the software. Discussion following each step was made to highlight aspects that need improvement. Following the training session, the examiners sketched 5 random SEM images independently and the similar process was repeated at one-month interval. The volumetric percentage of the obturated surface area were calculated using the following equation.

$$\text{Volumetric percentage of obturated canals (\%)} = \frac{\text{Adaptation of root filling material (mm}^2\text{)} - \text{Void (mm}^2\text{)}}{\text{Surface area of root canal space (mm}^2\text{)}} \times 100$$

The volumetric percentage of each obturated surface area obtained by each examiner was compared. Then, the subsequent comparison of the volumetric percentage of each obturated surface area was made between these examiners and a trained staff. The SEM images of the obturated surface area were basically from the same teeth that were evaluated in the previous studies involving the extracted single rooted mandibular premolars[36] and mandibular first molars.[37] The trained staff was the same person who evaluated the volumetric percentage of obturated surface area in the previous studies.[36,37] The evaluation of the reliability between two examiners and comparison with the previous studies were analysed using Intraclass Correlation Coefficient (ICC) with the following categories; ICC values <0.5: poor reliability, ICC values of 0.5-0.75: moderate reliability, ICC values of 0.75-0.9: good reliability, and ICC values >0.90: excellent reliability.[1]

SketchAndCalc™ Area Calculator Software

The SEM image of obturated root canal was uploaded into the canvas of this software. The canvas scale was set by dragging the calibration icon along the scale bar on uploaded SEM image. Unit of nanometer (nm) was chosen in the unit setting, then tracing can be started. Green colour was chosen for the outline of root canal wall. Sketching was completed by dragging the cursor in

order to make the continuous line. Line length was displayed throughout the drawing session to ensure the measurement was accurate. The examiners repeated the process until all areas of root canal wall were drawn. The surface area (nm^2) was automatically generated and displayed at the bottom right corner of the software layout. This process was then repeated by choosing pink colour to evaluate the material adaptation in the root canal space followed by blue colour for the voids within obturation materials. The adjustment of the lines was made by dragging the lines to the right position until the desired area was covered with the lines to ensure the accurate measurement were achieved in accordance with the uploaded SEM images. The results were displayed at the bottom right of the screen. Sketched images are shown in Figure 1.

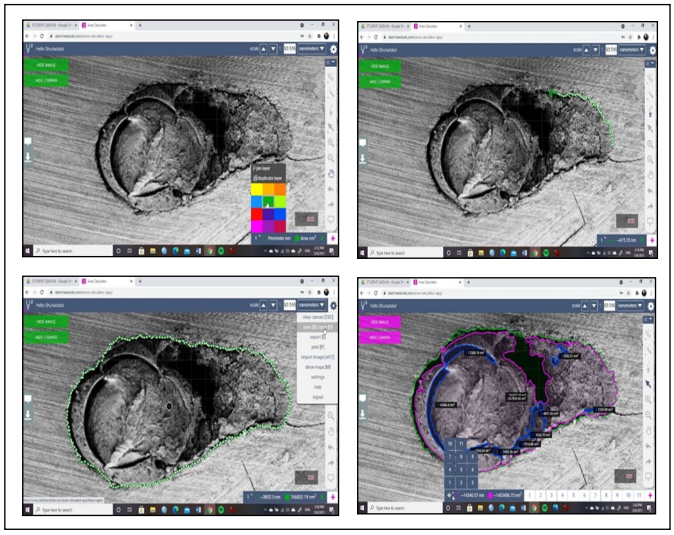

Figure 1: Sketch images showed three different colours to indicate the root canal wall (green), material adaptation in the root canal space (pink) and voids within obturation materials (blue)

Since this software was incorporated with measurements of metric and imperial system, the results displayed did not require manual conversion. When all the SEM images were sketched and the volumetric percentage of the obturated surface area were calculated, the results were compared to the previous studies. The analysis was done using SPSS version 25.0. The existence of a normaldistribution of the data sets was tested using Kolmogorov–Smirnov test followed by ICC. The analysis was done using an absolute-agreement, 2-way mixed-effects model of ICC with 95% confident interval. A two-way mixed-effect model based on single ratings and absolute agreement assessed the inter -examiner reliability for either examine. Mean estimations along with 95% confidence intervals were reported for each ICC.

RESULTS

Inter- and Intra-Examiners Reliability During Calibration

Excellent inter- (Table I) and intra-examiners (Table II) reliability were observed between examiner 1 and examiner 2 in the analysis of volumetric percentage of obturated surface area of 5 SEM images.

Table I: Inter-examiner reliability analysis

Examiners	ICC Values	95% Confident Interval	Interpretation
Examiner 1 & Examiner 2	0.997	0.991-0.999	Excellent agreement

Table II: Intra-examiner reliability analysis

Examiners	ICC Values	95% Confident Interval	Interpretation
Examiner 1	0.99	0.996-0.999	Excellent agreement
Examiner 2	0.982	0.948-0.994	Excellent agreement

Inter-Examiner Reliability

The ICC values in mandibular premolars and mandibular molars were 0.979 and 0.918 respectively, indicating excellent inter-examiner reliability (Figure 2).

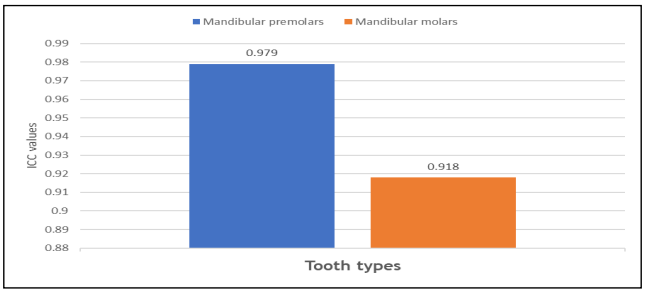

Figure 2: Inter-examiner reliability in mandibular premolars and mandibular molars

Inter-Examiner Reliability Between Two Examiners and The Previous Studies

When the findings of the mandibular premolars were compared between two examiners and to the previous studies, examiner 1 and examiner 2 showed the ICC values of 0.816 and 0.856 respectively, indicating good inter-examiner reliability. In the mandibular molars, the ICC values of examiner 1 and examiner 2 were 0.994 and 0.946 respectively, indicating excellent inter-examiner reliability (Figure 3).

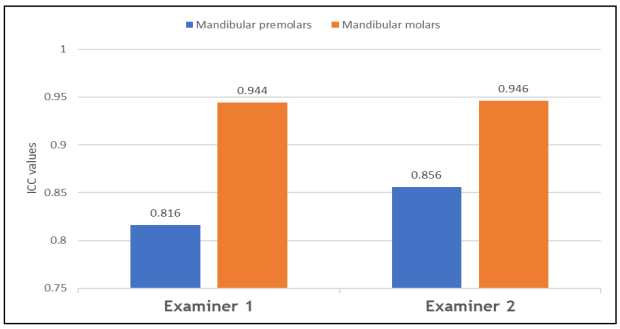

Figure 3: Inter-examiner reliability between two examiners and the previous studies

Combined Data Between Two Examiners and Comparison with The Previous Studies

The ICC values between two examiners and the previous studies was 0.844 in mandibular premolars and 0.962 in mandibular molars indicating good and excellent inter-examiner reliability respectively (Figure 4).

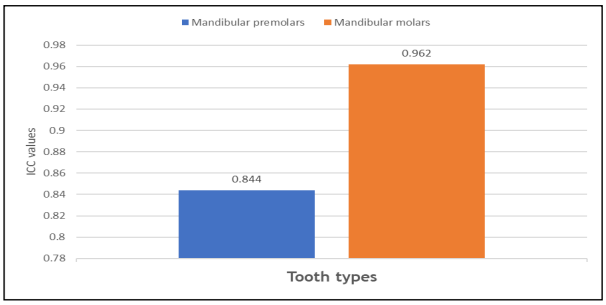

Figure 4: Combined data between two examiners and comparison with the previous studies

DISCUSSION

This study is the first step in assessing how reliable the software is with the goal to utilize it for the future biomedical research. As digital microscopy continues to evolve, the need for high resolution and quality of images has not changed. Nowadays, digital microscopy has become an important educational tool to reproduce the images from microscopes as accurately as possible.[42] Software can help to achieve this by providing modifications in regards to magnification, colour contrast and imaging enhancement from scanned images.[20]

Since the present study focused on the reliability of measurement produced by a software, it is rather difficult to compare the findings with published studies owing to wide variations in the software that have been used and unavailable reported data in assessing the reliability. The reasonable cost for the license of SketchAndCalc™ Area Calculator software and relatively easy to operate after multiple practices make this software convenient for evaluating the obturated surface area. The unique feature in this software allows us to set the drawing scale of any image before drawing the perimeter of the shape. Irregular areas that contain angles or curves can be easily calculated without complex geometry math. The uploaded images that are compatible with this software are .png .jpg .gif or .pdf and not restricted to any form of image. It can calculate the irregular area of the shape regardless of how complex it is just by drawing around the perimeter of the area. The calculator can even sum multiple area calculations together by way of drawing layers. After the first area has been calculated, a new drawing layer can be added, allowing for an unlimited number of area calculations to be performed.

The results of the area calculator are displayed in imperial and metric systems, increasing the calculator's utility, and removing the need to convert between different square area measurements. This, alongside the calculators precise drawing tools and magnification, ensures that irregular areas can be calculated accurately. The area calculator can also accommodate regular polygon shapes with fixed angles and precise line lengths. The constrained drawing tool snaps to common angles, and line lengths can be manually edited using the keyboard, helpful if the irregular area has a straight side or length. A curve drawing tool is another unique feature of this software. The aforementioned features are useful in the present study because the obturated surface area are unique, require multiple functions of the software to accurately reproduce the sketched images for evaluation of the volumetric percentage.

Throughout the process of sketching the SEM images, the examiners encountered some limitations with this software. Downloading of the completed sketch of an SEM image was sometimes unsuccessful or took approximately 45 minutes. The situations occurred for several times due to the maintenance routine without prior notice to the users. Fortunately, every complaint made by the examiners was responded in a short period of time by their staff through e-mail. The complaints reported include the interruption of web server in downloading images or problem to log in the software. These problems were

resolved within 24 hours after receiving complaints from the examiners. In the present study, inter-examiner reliability was selected because it is more appropriate considering the timeframe of our research project and the existing SEM images from the previous studies that we had in our record.[36,37] Excellent inter-examiner reliability was observed in the mandibular premolars and mandibular molars. The findings were consistent with the calibration stage, could be attributed to the effective training session, similar electronic device (HUION Digital Graphic Drawing Tablet H420), presence of sketch manual as a guide to the examiners in identifying the lines to be drawn on the SEM images, and discussion on refining the sketched images.

When the findings were compared to the previous studies, the inter-examiner reliability between both examiners and to the previous studies exhibited good results in the extracted single rooted mandibular premolars and excellent results in the mandibular first molars. These differences might be influenced by the exposure periods of both examiners with the software since the sketching session began with the SEM images of extracted single rooted mandibular premolars followed by mandibular first molars. Sketching period for the former took place when both examiners were still learning on how to sketch accurately and trying to acquaint with the software program. As both examiners were still learning, it took some times to get used to the software and electronic device.

Meanwhile, sketching period for the latter began when both examiners had acquainted skills and experience with the software and electronic device. Since both examiners had developed some skills and experience in sketching, the inter-examiner reliability of obturated surface area between them and to the previous study showed excellent results. Comparison to the previous studies were carried out because we want to assess whether the skills and experience of the users influence the results and whether the findings observed in the present study were consistent with the previous studies. This is because the findings from previous studies served as benchmarks and sketched by a trained staff. Since the findings observed in the present study were good to excellent inter-examiner reliability, we could suggest that the skills and experience of the users might influence the results. With adequate training, new users could potentially produce the results as good as the experienced users. However, intra-examiner reliability was not carried out because of beyond the scope of the present study. In addition to that, there were 60 SEM images involved and the procedure was time-consuming, therefore the analysis on an intra-examiner reliability was not possible. Perhaps, future research can be done to assess the intra-examiner reliability using similar SEM images included in the present study. Based on the results of the present study, SketchAndCalc™ Area Calculator software can be reflected as a reliable method to evaluate the obturated surface areas of the extracted single rooted mandibular premolars and mandibular first molars, and could potentially be utilized for the future biomedical research.

CONCLUSIONS

Within the limitation of the present study, the conclusion that can be suggested are:

1. Excellent inter-examiner reliability was observed in the extracted single rooted mandibular premolars and mandibular first molars.
2. Good and excellent inter-examiner reliability were observed between two examiners and to the previous studies involving the extracted single rooted mandibular premolars and mandibular first molars respectively.

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