

Volumetric Assessment of Ameloblastoma Applying Open Source Software and ABC/2 Estimation Technique

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ABSTRACT

Objective: To measure and compare the tumour volume from patients with ameloblastoma using MITK 3M3 open source software and ABC/2 estimation technique.

Design: Cross sectional study of secondary data obtained from patients with ameloblastoma attending Hospital Universiti Sains Malaysia.

Materials and Methods: Medical records were retrieved from January 2001 and December 2011 that consists of histologically benign and previously untreated ameloblastoma. Ethical approval of the study was obtained from the Research and Ethics Committee (Human), Universiti Sains Malaysia. Radiographical imagings were retrieved and analyzed using open-source MITK 3M3 software and ABC/2 estimation technique.

Results: The ratio of male to female patients diagnosed is 1.5:1. The range of age is from 17 to 37 years old with the mean age 31.1 and the most occurred age group is in the second decades of life. Out of 10 patients, 90% of ameloblastoma cases occurred in the mandible compared to the maxilla. The Wilcoxon Sign Rank Test analysis showed no significant difference in the volume measurements between MITK 3M3 software and ABC/2 estimation technique ($r = 3$, $p = 0.241$).

Conclusion: ABC/2 estimation technique provides accurate results for regular shape ameloblastoma volume as MITK 3M3 but underestimate the volume for complex and irregular shape of the tumour.

KEY WORDS

ameloblastoma, volume measurement, craniofacial imaging

INTRODUCTION

Ameloblastoma is a benign, slow growing, and locally invasive epithelial odontogenic neoplasm of putative enamel organ origin^(1,2). It has an equal sex distribution with peaks incidence in the 3rd to 4th decades of life. It is detected during routine radiography examination with a characteristic "soup bubble-like" appearance.

Advanced in craniofacial medical imaging and precise radiological evaluation of a lesion is important and have a significant impact on diagnosis and subsequent patient treatment⁽³⁾. In addition, it is important tools to aide in clinical assessment of the patients. Two-dimensional (2D) images such as orthopantomogram (OPG) and skull x-ray have certain short-comings, for example, superimposition of structures and difficult visualization. Three-dimensional (3D) imaging such as computed tomography (CT) and cone beam computed tomography (CBCT) scans have more advantages thus can be used as pre-operative assessment for craniofacial reconstruction. The advantage of the normal and abnormal anatomical structures is important especially for surgical planning.

The Medical Imaging Interaction Toolkit (MITK)⁽⁴⁾ 3M3 is an open source software application developed by German Cancer Research Centre and Mint Medical, Germany. The software supports manual and interactive segmentation of medical volumetric images⁽⁵⁾. Hence, the volume of ameloblastoma could be measured by using MITK 3M3 interac-

tive segmentation.

A simple estimation method of intracerebral hematoma volume, known as the ABC/2 or XYZ/2 method, was initially introduced by Kwak *et al.*⁽⁶⁾ and further validated by Kothari *et al.*⁽⁷⁾. It has been proven a reliable and simple volume measurement method of intracerebral haemorrhage⁽⁷⁾. The most common shape of intracerebral haemorrhage is round-to-ellipsoid, followed by irregular and multinodular⁽⁸⁾ which is similar to ameloblastoma. As far as we are aware, no study has applied ABC/2 estimation technique in measuring the volume of ameloblastoma.

Therefore, the aim of this study is to measure and compare the tumour volume of ameloblastoma using MITK 3M3 and conventional ABC/2 estimation technique.

MATERIALS AND METHODS

A cross sectional study of secondary data of 22 patients with ameloblastoma were chosen. Ten patients were selected based on our inclusion criteria who had undergone CT/CBCT scans investigation between January 2001 to December 2011 in Hospital Universiti Sains Malaysia (HUSM) with ameloblastoma prior to surgical intervention. Ethical approval was obtained from the Human Research and Ethics Committee, Universiti Sains Malaysia [No 249.4.(1.17)]. Radiological

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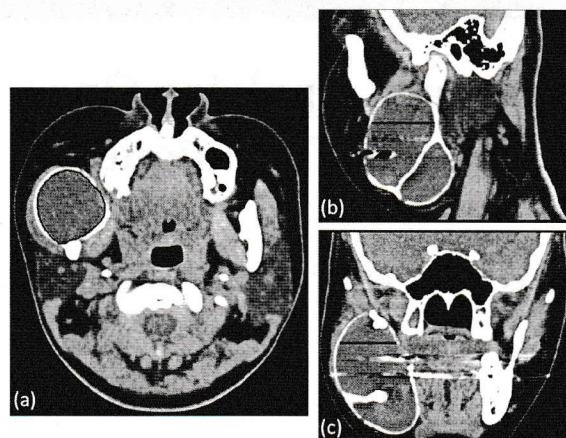


Figure 1. Tumour segmentation of right mandible shown in (a) Axial (b) Sagittal and (c) Coronal views

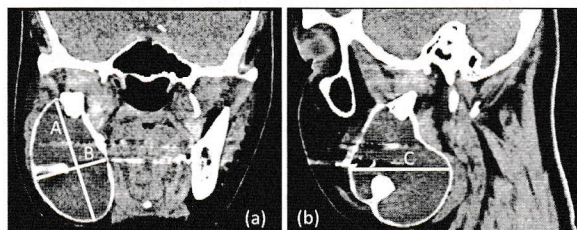


Figure 3. Maximum cross diameter of A and perpendicular bisector B in Coronal view (a) and depth C in Sagittal view (b) obtained by MITK 3M3

data acquisition were obtained from CT and CBCT scanners using CT Siemens Somatom Definition AS with 1 mm slice thickness and CBCT Planmeca Promax with 0.32 mm slice thickness respectively.

3D Volumetric Measurement using MITK 3M3

The tumour segmentation was performed slice by slice from axial view using region growing method^{9,12)} which has been widely used in image processing for segmentation in CT images such as liver¹³⁾, prostate, bladder and rectum¹⁴⁾, skeletal structures¹⁵⁾, and nasopharyngeal carcinoma^{16,17)}. The coronal and sagittal views in MITK 3M3 which showed concurrent images were used as a control to detect over segmentation (leakage) or under segmentation (Figure 1).

When all the axial slices had been segmented, the tumour volume was calculated and displayed. The 3D volume of the tumour was rendered and visualized to see the extent of tumour as shown in Figure 2.

The tumour segmentation and volume measurements were repeated by three observers and the mean estimated tumour volume was taken.

ABC/2 Estimation Technique

ABC/2 estimation technique is derived from an approximation of the formula for volume of ellipsoids^{18,19)}. The volume of an ellipsoid is $4/3\pi (A/2)(B/2)(C/2)$, where A, B and C are the three diameters. If π is estimated to be 3, then the volume of an ellipsoid becomes $ABC/2$ ¹⁸⁾. Prior to applying this method, the maximum cross-sectional diameter was determined using the measurement tool in MITK 3M3. The volume of ameloblastoma was calculated using the formula of ellipsoids where the maximum diameter obtained above (A) multiplied by perpendicular diameter (B) multiplied by the depth (C) and divide by 2 (Figure 3). The volume estimation was conducted by three observers and the mean estimated tumour volume was taken.

Data analysis

Descriptive analysis was performed to calculate the frequency and percentage of the variables. Comparison between MITK 3M3 and ABC/2 to evaluate the volume was analysed using Wilcoxon Sign Rank Test.

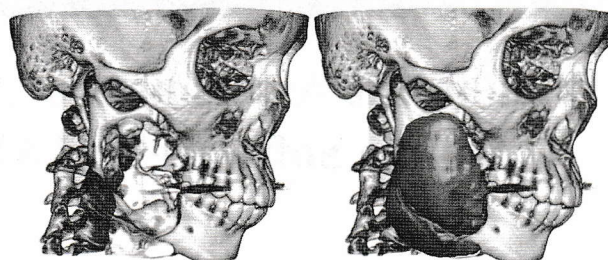


Figure 2. 3D visualization of the ameloblastoma before (left) and after (right) segmentation showing the extent of the tumour

Table 1. The measurements of tumour volume from patients with ameloblastoma using MITK 3M3 and ABC/2

Patient's No	Age (years)	Gender	Location	Volume measurements (ml)		
				MITK	ABC/2	Difference
1	32	M	Mandible	17.30	15.92	-1.38
2	47	M	Mandible	106.00	105.67	-0.33
3	18	M	Mandible	37.90	33.70	-4.20
4	17	M	Mandible	12.80	14.02	1.22
5	23	M	Mandible	46.70	49.52	2.82
6	37	M	Mandible	37.80	33.14	-4.66
7	33	F	Mandible	3.00	2.15	-0.85
8	32	F	Mandible	83.30	86.89	3.59
9	37	F	Mandible	76.10	73.74	-2.36
10	35	F	Maxilla	153.40	122.69	-30.71

Significance level was set at 5%

RESULTS

Results of volume measurements and patients' demographic data are shown in Table 1. The ratio of male to female patients diagnosed is at 1.5:1. The range of age is from 17 to 47 years old with the mean age 31.1 (SD = 9.3) and the most frequent age group is in the third decades of life. Out of 10 patients, 90% of ameloblastoma cases occurred in the mandible compared to the maxilla. A Wilcoxon test was conducted to compare between MITK 3M3 software and ABC/2 estimation technique. The results showed no significant difference, $p = 0.241$, $r = 3$.

DISCUSSION

In the present study, the average age was 31.1 comparable to previous studies by Siar *et al.*¹⁾ (mean = 30.3), Akinosi *et al.*²⁰⁾ (mean = 31.2) and Darshani *et al.*²¹⁾ (mean = 33.2). The gender inclination shows a male to female ratio of 1.5:1 with male predominance which is similar to that reported by Siar *et al.*¹⁾ (1.4:1) and Jing *et al.*²²⁾ (1.4:1). 90% of ameloblastoma were found in the mandible compared to maxilla, similar to a Siar *et al.*¹⁾ study (91.5%) and Ueno *et al.*²³⁾ study (93.2%).

Manual segmentation using MITK 3M3 provides accurate and precise volume measurement but the process was tedious and time consuming. This method was still favourable because the tumour could be visualized in 3D for the pre-operative assessment (Figure 2). On the other hand, the ABC/2 estimation technique offers fast calculation of ameloblastoma volume however the tumour volume was just an estimation. The results showed no significance difference from MITK 3M3 except for patient no 10 where the irregular ameloblastoma involved the Maxilla and the ABC/2 method underestimated the volume compared to MITK 3M3.

The ABC/2 estimation technique was accurate when estimating volume in tumours with consistent margins but was not accurate for volumes in irregular margins when compared to MITK 3M3 in agreement with Luccichenti *et al.*²⁴⁾, Tsair *et al.*²⁵⁾ and Pedraza *et al.*¹⁹⁾. They concluded that volume measurements estimation acquired through linear

measurements was not reliable to estimate the volume of irregular-shaped solids.

The irregular shape of the tumour does not affect the manual volumetric segmentation using MITK 3M3 as the tumour was segmented slice by slice. Therefore, manual segmentation is still a gold standard when it comes to segmenting irregular shape of tumour.

CONCLUSION

Manual segmentation is still the best solution to measure the volume for irregular and complex shape of the tumour. However, the measurement of tumour volume using ABC/2 estimation technique provides fast and accurate results similar to manual slice-by-slice segmentation method in MITK 3M3 as long as the shape of tumour is closer to the shape of an ellipsoid and regular in shape.

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