

ORIGINAL ARTICLE | Head and Neck Imaging

Evaluation and comparison of Gray scale value measurements of odontogenic cysts and tumors using Cone Beam Computer Tomographic images: A cross sectional study

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ABSTRACT

Purposes: Studies on gray scale value (GSV) done over the past decade showed that there is linear relationship between GSV in CBCT and HU in CT. In our study, we evaluated and compared the GSV of 30 odontogenic cysts, 30 odontogenic tumors and 30 normal (cancellous and cortical) bone.

Materials and methods: GSV at the epicentre of the odontogenic cysts and tumors, maximum and minimum GSV within the lesions and normal (cortical and cancellous) bones were evaluated and compared.

Results: The median GSV of odontogenic cysts and tumors ranged from -66 to +60 and -89 to +679 respec-



KEY WORDS

Odontogenic Cysts, Odontogenic Tumors, Gray Scale Value, Cone Beam Computed Tomography, Epicentre



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tively at epicentre and found to have very high significance ($p=0$) between the GSV of odontogenic cysts, odontogenic tumors and normal bone values.

Conclusion: GSV in CBCT can be considered as investigative tool for the diagnosis of odontogenic cysts and tumors.

Introduction

Rapid evolution in technology, have revolutionized Cone beam computed tomography (CBCT) with better image quality and accuracy enabling CBCT with wide variety of applications like routine diagnosis, assessment of complex maxillofacial pathologies and their treatment planning.^{1,2,3} Attenuation of x ray by any structure is calculated in absolute units of inverse length (mm^{-1} or cm^{-1} , μwater). Value of μwater is measured by reconstructing a calibration phantom consisting of water-equivalent material which is designated as Hounsfield Unit (HU) in computed tomography (CT). In CBCT, this degree of x-ray attenuation is showed by "Gray scale value" (GSV) (voxel value) measurements.¹ Although, GSV in CBCTs are considered as approximate values and thus cannot be expressed as HU, a large number of studies have shown a linear relationship between HU in CT scan and GSV in CBCT, which can be used for the estimation of bone density.^{2,3} Analysis of the hard tissue changes and bone density in the radiographs helps in early diagnosis of the bony pathologies.

Hence this study is an attempt to evaluate and compare the GSV measurements in CBCT as a diagnostic tool to differentiate odontogenic cysts and tumors.

Methodology

The present radiographic study consisted of CBCT images of 30 odontogenic cysts, 30 odontogenic tumors and 30 normal bone who were aged between 7 to 74 years from the Radiology database, who visited the department for the evaluation of bony pathology and for various diagnostic and therapeutic purposes. The study was approved by the institutional review board and ethical committee. All the images were taken in Kodak Care stream CS 9300 Cone Beam Tomography Machine with exposure factor of 90.00 kVp, 5 mA 8.015s.

Procedure:

Based on histopathological report, 30 CBCT images of odontogenic cysts and 30 CBCT images of odontogenic

tumors were selected as group A and group B respectively. 30 CBCT images of normal bone were selected for group C from the data base. Then all the data were evaluated for the following:

- For Group A and B
 - GSV at the epicenter of the odontogenic cysts and odontogenic tumors.
 - Minimum and maximum GSV of odontogenic cysts and odontogenic tumors.
- For Group C
 - Minimum and maximum GSV in the normal cancellous and cortical bone in the #16 and #46 region.

1. GSV evaluation at the epicenter for Group A and Group B:

GSV for Odontogenic Cysts, Odontogenic Tumors were determined at the epicenter of the lesion.

Determining the epicentre:

The measurements were done in the custom slicing section and the evaluation was done with the help of a reference point. First, the epicenter of the lesion was determined for odontogenic cysts and odontogenic tumors by using the reformatted panoramic view, center of the lesion was determined by measuring the size of the lesion using the scale tool available in the software. The mouse point was placed at "epicenter" the GSV at this point was recorded as "epicenter GSV" (Figure 1 and 2).

Determining the maximum and minimum GSV: In the same view the minimum and maximum GSV within the lesion was also recorded by scrolling the pointer throughout the lesion. The lowest value was recorded as minimum GSV and highest value was recorded as maximum GSV.

Evaluation of GSV of normal bone (minimum and maximum GSV): The evaluation of cortical and cancellous bone was done at the first molar region (#16 in maxilla and #46 in mandible) by scrolling the mouse cursor throughout the area. Mouse pointer was scrolled throughout the cortical bone in this area and lowest value was recorded as minimum cortical bone GSV and highest value was recorded as maximum cortical bone GSV. Similarly, for the cancellous bone GSV the mouse

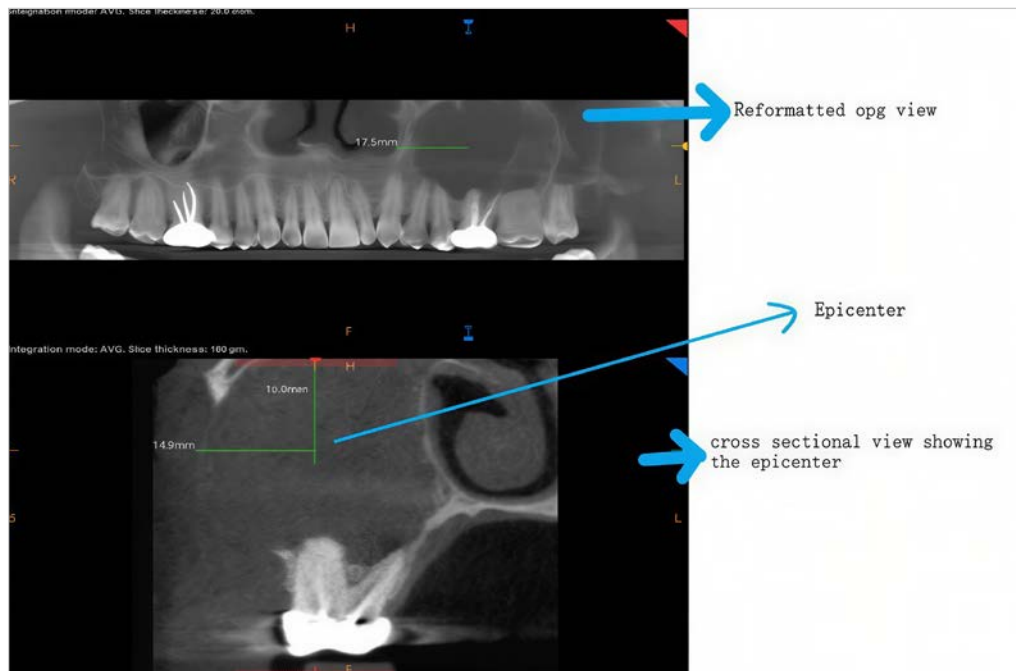


Figure 1: Locating epicentre

Cone Beam Computed Tomography (CBCT) evaluation of the lesion.

The reformatted orthopantomographic (OPG) view demonstrates a well-defined radiolucent lesion involving the left maxillary sinus region, measuring approximately 17.5 mm in greatest dimension. The cross-sectional CBCT image identifies the epicenter of the lesion within the maxillary sinus, with dimensions of approximately 14.9 mm × 10.0 mm, aiding in the assessment of its extent and anatomical relationship to adjacent structures.



Figure 2: GSV calculation at epicentre

CBCT multiplanar and three-dimensional reconstruction demonstrating lesion localization and extent.

The CBCT images show custom slicing used to localize the lesion and determine its epicenter. The reformatted panoramic view reveals a well-defined radiolucent lesion associated with the posterior mandibular region. The cross-sectional image demonstrates the epicenter of the lesion, with the cursor positioned at its center for precise measurement and assessment. The reconstructed three-dimensional (3D) view provides visualization of the lesion's relationship to the surrounding osseous structures, while the grayscale value (GSV) recorded at the epicenter aids in radiodensity evaluation.

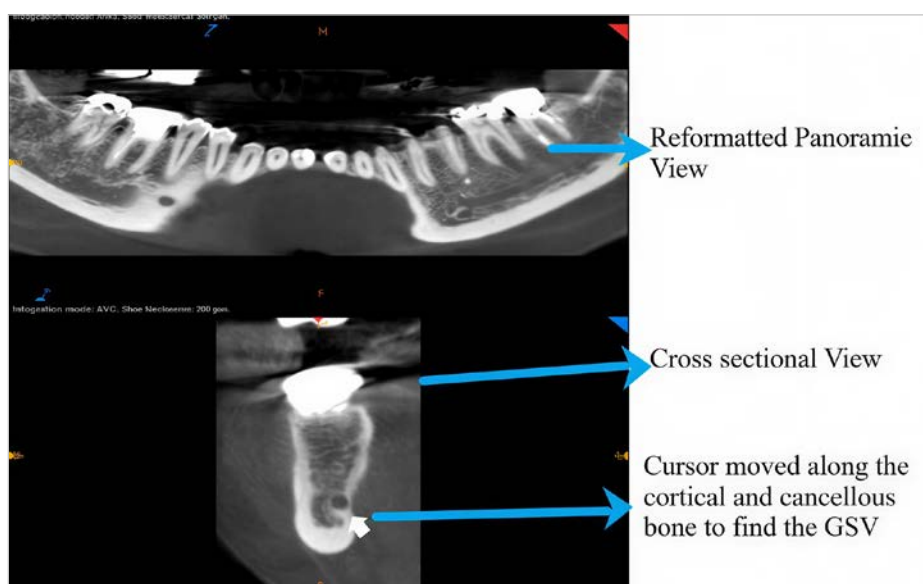


Figure 3: GSV calculation of cortical bone
CBCT assessment of mandibular bone density using grayscale value (GSV) analysis.

The reformatted panoramic view demonstrates the location of the region of interest within the mandible. The corresponding cross-sectional image was used to evaluate bone density, with the cursor sequentially positioned within the cortical and cancellous bone compartments to obtain grayscale value (GSV) measurements. This analysis facilitates comparison of radiodensity characteristics between cortical and trabecular bone.

pointer was scrolled throughout the cancellous bone in the selected cross-sectional area (Figure 3). All the CBCT images were analyzed by two Oral Radiologists in an interval of one month.

Statistical analysis: The collected data were statistically analyzed with the SPSS VERSION 21.0 software. (Statistical Package for the Social Sciences - SPSS). The continuous variables were expressed as mean $\pm$ Standard Deviation (SD). Categorical variables were expressed as Frequencies and Percentages. "ONE WAY ANOV A or KRUSKAL-WALLIS ANOVA" used for comparing the samples.

Results: The age ranged between 7 years to 65 years (average 31 years) for odontogenic cysts, 11 years to 63 years (average of 34 years) for odontogenic tumors. In this study, 33.3% were females and 66.7% were males accounting up to 1:2 female to male ratio for odontogenic cysts and 1:1 for odontogenic tumors.

Odontogenic cysts: The GSVs ranged from -66 to +60 at the epicenter with median of 0.0, minimum and maximum GSV within the lesion ranged from -571 to +187 with median of -315.5. Out of 30 odontogenic cysts, 6 were dentigerous cysts (4 in maxillary region and 2 in

Table 1: Comparison of GSVs of different types of Odontogenic Cysts

Type of Cyst	Number of images evaluated	Minimum mean value of GSV	Maximum Mean value of GSV	Median	Epicenter value (minimum)	Epicenter value (maximum)	Median of Epicenter GSV
Radicular cyst	17	-521	+131.5	-332	-661	+60	-453
Dentigerous cyst	6	-365	140	-286.3	-663	206	-285
Odontogenic keratocysts	7	-571	+187	-59.5	-600	+206	+35

Table 2: Comparison of GSV between different types of Odontogenic Tumor

Type of Cyst	Number of images evaluated	Minimum mean value of GSV	Maximum Mean value of GSV	Median of GSV	Epicenter Minimum value	Epicenter Maximum value	Median Epicenter GSV
Ameloblastoma	26	-365	+140	+158.5	-663	+206	+51
Other tumors	4	+89	+468	+272.5	+84	+585	+253

Table 3: Average GSV of Minimum and Maximum GSV (Cancellous bone v/s Cyst and tumors)

Type of Cyst	N	Minimum	Maximum	Median	IQR	Kruskal-wallis	P value
Normal (Cancellous)	30	-348	1234	651.5	769	43.55	0.00*
Cyst	30	-571	187	-315.5	233.4		
Tumor	30	-549.5	468	158.5	315.1		

*significant

Table 4: Comparison of GSV at Epicenter

Type of Cyst	N	Minimum	Maximum	Median	IQR	Mann-Whitney	P value
Normal	30	-	-	-	-	286.0	.015
Cyst	30	-66	60	0.00	32		
Tumor	30	-89	679	85	264		

*significant

mandibular region), 7 were odontogenic keratocysts (3 in maxillary regions and 4 in mandibular regions) and 17 were radicular cysts (9 in maxillary regions and 8 in mandibular regions). GSV at epicenter of radicular cyst, dentigerous cyst and odontogenic keratocysts were -453, -285 and +35 respectively (Table 1)

Odontogenic tumors: The GSVs ranged from -89 to +679 with median of +32 at the epicenter for the odontogenic tumors. Minimum and maximum value ranged from -549.5 to +468 with median of +315.1. Out of 30 odontogenic tumors, 26 cases were ameloblastoma (2 in maxillary regions and 24 in the mandibular regions) and 4 were other odontogenic tumors (1 in maxillary region and 3 in the mandibular regions). GSV of amelo-

blastoma at epicenter was +51, while for other tumors was +272.5. (Table 2)

Comparison of GSV of Normal Cortical bone v/s Odontogenic Cysts and Odontogenic Tumors: Kruskal Wallis test had been done for comparing the difference between GSVs of each group and value obtained as 60.77 with a P value of 0.00 which denotes very high significance. This indicates that, there was statistically significant difference in GSVs of normal cortical bones with GSVs of odontogenic cysts and odontogenic tumors.

Comparison of GSV of Normal Cancellous bone v/s Odontogenic Cyst and Odontogenic Tumor: On comparison, with 3 groups, Kruskal Wallis value was 43.55 with

a P value of 0.00 which is very highly significant. That means similar to the cortical bone, there was a significant GSV difference between cancellous bone v/s cysts and tumors values. (Table 3)

Comparison of GSVs of Odontogenic Cysts v/s Odontogenic Tumors at epicenter: To check the significance, we applied Mann Whitney test whose value was 286.0 ($P=0.015$, $P<0.01$ = high significant) which indicates high statistical significance. That means to say that there is value difference between the epicenter GSVs of Cysts and tumors. (Table 4)

Discussion

In CT, HU is used to differentiate between different lesions and normal structures by measuring radiodensity and quantitative scale of the images. HU value for different elements and tissues ranges from -1000 to +3000 (air v/s bone) which helps in evaluating between benign and malignant lesions. In fluid filled radiolucent lesions HU value ranges from -1000 to +40 and in radiopaque lesions with bone ranges from +700 to +1000. In CBCT, even though there were no standard values like HU in CT, comparable value available is GSV. GSV is the difference in the shades of Grey from white to black. In CBCT imaging, GSV measures the blackness or whiteness. Accordingly, GSV ranges from 0 (black) to 255 (totally white) for 8-bit detector. All the CBCT available are capable of recording GSV difference of 12 bit or above¹. A 12 bit detector provides 212 or 4096 shades to display contrast. A 16 bit detector provides 216 or 65,536 shades of gray. Although a single cone-beam rotation may take less than 20 seconds, it produces 100 to more than 600 individual projection frames, each with more than 1 million pixels with 12 to 16 bits of data assigned to each pixel. These data are processed to create a volumetric data set composed of cuboidal volume elements (voxels) by a sequence of software algorithms in a process called reconstruction¹. In our study, we have used Kodak Carestream 9300 mid-range version, in which it uses 14-bit detector which provides 214 or 16384 shades of gray.

Minimum and maximum GSV found to be -315.5 (-571 to +187) for the Odontogenic Cyst, +315.1 (-549.5 to +468) for odontogenic tumors, +1479.5 (+80 to +2100) for cortical bone, and +651.5 (-348 to +1234) for cancellous bone. This showed that there is significant difference be-

tween the GSV of cysts, tumors, normal cancellous and cortical bone ($p=0.00$, very high significance). Cysts are fluid or semi fluid filled cavity or sac lined by epithelial lining and tumors are of solid soft tissue lesion with less dense areas in between. GSV for the air is -1000 and value increases as the lesion became hyper dense. In our study we got negative GSV for the cyst while positive value for the GSV of tumors, showing high statistical significance. This indicates possibility of considering the GSV measurements in differentiating fluid filled cavity like cyst and solid filled lesions like tumors.

Similarly, Simon et al study in 2006, ² analyzed minimum, maximum and epicenter GSV of CBCT (NewTom 3G) on 17 large periapical lesions and found a strong reliability in differentiating cyst and granuloma using GSV in CBCT. Simon et al proposed that, to get an accurate reading, the whole lesion should be scanned for the most lucent and least dense areas. Thus, they revealed that a positive GSV might indicate solid filled lesion while the negative GSV may indicate semi solid or fluid filled area.

Nasim et al in 2018,¹ conducted a study to evaluate the GSV of odontogenic cysts and odontogenic tumors at epicenter of CBCT images taken in "Sirona GALILEOS comfort CBCT scanner". They found statistically significant difference between GSV of cyst and tumor as in our study. However, in their study GSV obtained for cyst as 1292.2 ± 6.4 and for tumor as 1469 ± 70.4 at the epicenter, which was higher than our study. Similarly, Chaudhari et al in 2020, ⁴ conducted study on differentiating various bony lesions in jaw using GSVs in CBCT of 72 CBCT scans, using SIRONA ORTHOPHOS XG 3D CBCT machine. In this study, mean value with SD of GSV for cystic lesions was 1208.375 ± 93 and for that of the tumor group was 1603 ± 425.5 . In both the studies values were higher than the values in our study, could be due to the difference between the machine used in their and in our study. We have used Kodak 9300 CS with bit depth of 14 which has 214 shades of gray. In both the studies, they have considered Sirona CBCT for their studies which have bit depth of 12 with 212 shades of gray. Both the studies have comparatively similar values for cysts and tumor. As there is no standardization for the GSV for different CBCT machines as in standardized HU value in CT, attributing a particular value for cyst and tumors may not be possible. However, irrespective of the machine used, there was sig-

nificant difference between the GSV of cyst and tumor, indicating that cyst value ranged in the lower grade as compared to the tumor value.

Bit depth in each machine is different based the manufactures desires. It ranges from 12 bit to 16 bits. 3D Accuitomo (Morito), Kodak CS 9300, 3D eXam (KaVo), i-CAT FLX, NewTom 5G uses 14-bit depth while Sirona, Skyview uses 12bit depth. Whitefox cbct machine uses 16-bit depth scanners 5. As the bit depth increases, the availability of shades of gray in each pixel increases which can influence the GSV. Apart from this, higher noise levels, more scattered radiation, high heel effect and beam hardening artifacts can add to the limitation in standardization of GSV in CBCT. Further, Hua Y et al⁶ revealed that field of view, and image acquisition settings are the other factors that may affect GSV. In our study we have used same FOV, and image acquisition setting for all the patients, thus eliminating the possibility of these factors affecting GSV obtained in our study.

In our study, GSV for cortical and cancellous bone were +1479.5 (+80 to + 2100) and +651.5 (-348 to +1234) respectively. Study by Arisan et al,⁷ determined correlation between CT and CBCT based on GSV, found gray density value to be 229 to 1,042 GSV. Another study by Magat et al⁸ in 2018 who evaluated GSV of mandibular bone in CBCT and found that trabecular bone had density of $+1583.5 \pm 554.52$ similar to that of cortical bone value in our study. Patrick et al.⁹ in 2017 evaluated the correlation between HU of MSCT scans and GSV in CBCT in various fields of view for hyper dense as well as hypo dense structures. In their study, the gray values for hypo dense structures in large-volume CBCT scans were more reliable and analogous to HU in MSCT. But for hyper dense structures, GSV of CBCT may not be as accurate as the HU value of a CT scan. These differences

could be attributed to different technique factors, dynamic differentiation of CBCT scanners, FOV, and scanning parameters. With the increasing radiopacities, the impact of beam hardening effect is more apparent. The radiographer should be aware of the phenomena and account for conceivable implications in clinical decision making.

In 2014, Mishra et al conducted Comparative study of CBCT and CT in the radiographic evaluation of cysts and tumours of the jaws for diagnostic quality and dimensional accuracy.¹⁰ They concluded that CBCT are more convenient and suitable than CT for the evaluation of bony lesions of the jaws caused by cysts and tumours and CBCT could provide an image with diagnostic quality and accuracy, with a lesser radiation dose and risk, at a lower cost as compared to CT.

Conclusion

GSV of cysts, tumors and normal bone in our study had significant differences in their value. Thus, we can say that, GSV can be considered for differentiating the Cysts, Tumors and Normal bone. Based on our finding, we also recommend that in the future, further studies on the effects of FOV, exposure parameters and image settings on GSV in CBCT images should be conducted. Also, assessment of GSV in CBCT in the other field of radiological evaluations like for implant site evaluations, bone density measurements, lesion healing evaluations etc should be considered. Similarly, more studies needed on deriving HU from the GSV of different CBCT machines.

As CBCT machine provides images with better sub millimetre resolutions, and linear accuracy with relatively lesser radiation and lower cost, it is recommended to use CBCT as an important assessment tool in the analysis of jaw lesions.

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