Available onlineat https://ejournal.unisayogya.ac.id/ejournal/index.php/ijhst

International Journal of Health Science and Technology, 3 (3), 2022, 10-16

Differences in the quality of paranasal sinuses CT images in sinusitis case by slice thickness variations

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Submission date: March 10, 2022 Revision date: April 5, 2022 Receipt date: April 11, 2022

Abstract

One of the parameters that has an effect on the quality of paranasal sinuses CT image is slice thickness. According to Zojaji et al (2015), paranasal sinuses CT Scan with an indication of sinusitis should be made with a slice thickness of 5 mm, while at the Department of Radiology of Telogorejo Hospital Semarang, paranasal sinuses CT Scan is made with a slice thickness of 3.2 mm. This study aims to find out the effect of variations in slice thickness setting in imaging quality and determine the best setting of the three selected slice thicknesses in producing high quality of the paranasal sinuses CT image. This study was conducted at the Department of Radiology of Telogorejo Hospital, Semarang. The research sample is a paranasal sinuses CT of coronal slices in cases of sinusitis taken by accidental sampling techniques. Data regarding the quality of the paranasal sinuse CT image were collected through a check list by five radiologists. The results of the study showed that there were differences in the quality of images by three slice thicknesses. The three best slice thickness settings to produce high quality image were 3.2 mm, then 5 mm and the last 7.5 mm.

Keywords: paranasal sinuses, CT image, sinusitis, slice thickness

INTRODUCTION

Rhinosinusitis, the symptomatic inflammation of the nasal cavity and sinuses (Rosenfeld et al, 2015; See, 2015), can be divided into rhinitis and sinusitis, yet the two terms are often combined because the nasal mucosa and sinus mucosa are often inflamed synchronously (Frerichs and Brateanu, 2020). It is one of the most commonly treated conditions in ambulatory care, but the presentation is often similar to that of other upper respiratory tract infections, and accurate diagnosis is difficult (Aring and Chan, 2016). Symptoms commonly include nasal drainage, nasal obstruction, and facial pain or pressure. Other symptoms can include fever, headache, cough, ear pain or pressure, and anosmia (Kroll et al, 2017).

Sinusitis affects about 1 in 8 adults in the United States, resulting in over 30 million annual diagnoses (Blackwell et al, 2014). The direct cost of managing acute and chronic sinusitis exceeds $11 billion per year (Blackwell et al, 2014), with additional expense from lost productivity, reduced job effectiveness, and impaired quality of life (Rudmik et al, 2014).

Doi: 10.31101/ijhst.v3i3.2440

Sinusitis is diagnosed by evaluation of the patients history and physical examination, because clinical evaluation is usually sufficient to diagnose sinusitis in most cases and empirical treatments are cheap and safe. However, when symptoms are recurrent or persistent despite appropriate treatment, imaging of sinusitis may be required for further evaluation (Rosenfeld et al, 2015). Imaging is reserved for cases of complicated rhinosinusitis, recurrent sinusitis, chronic rhinosinusitis, and immunocompromised patients (Kroll et al, 2017).

Plain radiography imaging can detect mucosal thickening, air fluid levels, opacification of the sinuses, anatomic variants, and foreign bodies (Aring and Chan, 2016), but it has poor sensitivity and specificity for sinus disease and thus is not usually recommended (Lau et al, 2022). CT of the sinuses has become the gold standard for sinus imaging in the case of complicated sinus disease because of improved visualization of sinus anatomy (Kroll et al, 2017). Cone-beam CT, a technique that creates 3-dimensional images of bony and soft-tissue structures of the face, is used primarily in dental imaging to evaluate the structures of the face, nasal cavity, and sinuses (FDA, 2020). It may be useful in the assessment of odontogenic sinusitis and maxillary sinus involvement (Kirsch et al, 2017). Magnetic resonance imaging (MRI) with and without intravenous contrast may be used to evaluate sinus disease, but it is not often the first imaging test performed (Frerichs and Brateanu, 2020).

CT without contrast enhancement is the gold standard of sinus imaging and often the first test performed when complications of rhinosinusitis are suspected, as it affords the best delineation of bone and allows for visualization of bony integrity and erosion. Findings on CT suggestive of sinusitis include thickened mucosa (> 4 mm), air fluid levels, and opacification of the sinuses (Kelly et al, 2018). According to Zojaji et al (2015), paranasal sinuses CT scan to patients with an indication of sinusitis should be made with a slice thickness of 5 mm for standard CT Scan and slice thickness of 3 mm for 4 slices CT Scan, while at the Department of Radiology of Telogorejo Hospital, Semarang, with standard CT Scan (dual slices) it is made with a slice thickness of 3.2 mm as the reformat result of a slice thickness of 7.5 mm.

In the paranasal sinuses CT Scan protocol commonly used in the Department of Radiology of Telogorejo Hospital, Semarang, the slice thickness options provided are 3.2 mm, 5 mm and 7.5 mm. Of the three slice thickness sizes, 7.5 mm is used which is then reformatted to 3.2 mm. This study aims to determine the difference in the quality of paranasal sinuses CT Scan images in sinusitis case between the slice thicknesses of 3.2 mm, 5 mm and 7.5 mm and to determine which slice thickness produces the best quality of paranasal sinuses CT Scan image in sinusitis case.

RESEARCH METHODS

This was an experimental study. The study was conducted by providing three treatments on paranasal sinuses CT Scan examination among patients with sinusitis, namely by using slice thicknesses of 3.2 mm, 5 mm and 7.5 mm on coronal slices. The three treatments were given to see whether or not there was a difference in the quality of the resulting CT Scan images and to determine the best treatment.

This study was conducted at the Department of Radiology of Telogorejo Hospital, Semarang. The data collection was conducted from December 2007 to January 2008. The study object in this Scientific Paper was three patients with indication of

ISSN 2685-8673 (online)

sinusitis. Meanwhile, the study subjects were coronal slices of paranasal sinuses CT Scan images in sinusitis case. The respondents in this study were radiologists.

In this study, the authors collected data by providing a check list to 5 respondents, namely the radiologists to provide an assessment on each paranasal sinuses CT Scan image in the form of numerical data so as to be further precessed in statistical analysis. Data analysis was conducted by non-parametric Friedmen's test statistical test. The test results were then used as the basis for developing conclusions.

RESULTS AND DISCUSSION

An assessment by the respondents (radiologists) was carried out based on the samples of paranasal sinuses CT Scan images in sinusitis case by three variations of the slice thickness size had been taken. The quality assessment of the paranasal sinuses CT Scan images was performed using a check list. Each check list consisted of 19 question items with a value range of 1-3 so that each image might obtain a minimum value of 19 and a maximum value of 57.

Table 1. The Results of Image Quality Assessment of Paranasal Sinuses CT Scan in Cases of Sinusitis

Respondent	Images A (3.2 mm)	Image B (5 mm)	Image C (7.5 mm)
1	50.00	46.00	40.00
2	50.33	43.33	41.67
3	51.67	47.00	42.33
4	47.67	43.00	41.00
5	49.67	46.00	42.00

From the table 1 above can be seen the results of assessment by 5 radiologists against paranasal sinuses CT Scan images in sinusitis case with three variations of the slice thickness size.

Table 2. Mean Results of The Image Quality Assessment of Paranasal Sinuses CT Scan in Cases of Sinusitis

Sample of Group	Number of Sample	Mean	Std Deviation
Slice thickness 3.2 mm	5	49.87	1.44
Slice thickness 5 mm	5	45.07	1.78
Slice thickness 7.5 mm	5	41.40	0.92

Based on the table 2 regarding the results of quality assessment of paranasal sinuses CT Scan images in sinusitis case, it can be seen that the paranasal sinuses CT Scan image with a slice thickness of 3.2 mm showed the highest mean value of 49.87 with a standard deviation of 1.44. The paranasal sinuses CT scan image with a slice thickness of 5 mm showed a moderate value of 45.07 with a standard deviation of 1.78. Meanwhile, the paranasal sinuses CT scan image with a slice thickness of 7.5 mm showed the lowest value of 41.40 with a standard deviation of 0.92.

Paranasal sinuses CT scan images by slice thickness variations are presented in the following figure:

ISSN 2685-8673 (online)

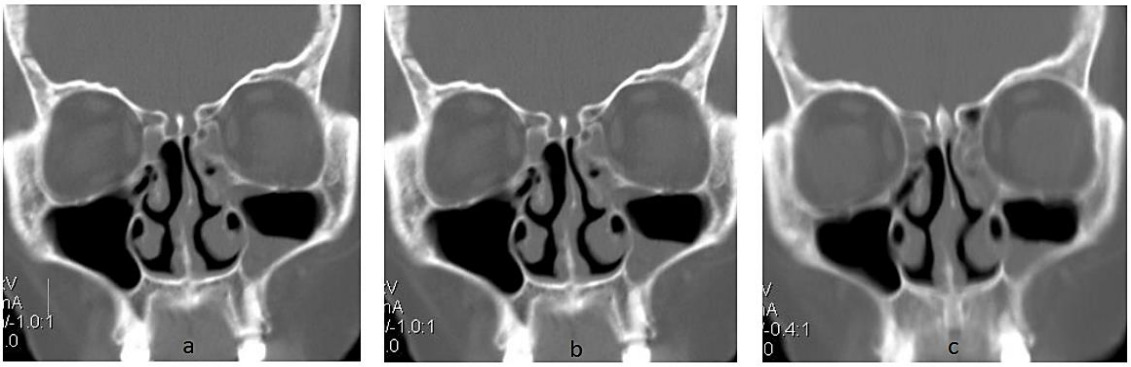

Figure 1. Paranasal Sinuses CT Scan Image (a). slice Thickness of 3.2mm (b) Slice Thickness of 5mm (c) Slice Thickness of 7.5mm

After the data were completely obtained, a Friedman test was performed to determine a significant difference among the results of the paranasal sinuses CT Scan image quality assessment by slice thickness variations in sinusitis case.

Based on the results of the Friedman test analysis, the study findings indicated that the p value in the asymptotic sign/asymptotic significance column was 0.007 or the probability was below 0.05 (0.007<0.05). Thus, it can be concluded that there are significant difference in the quality of the paranasal sinuses CT Scan images in sinusitis case between the slice thickness sizes of 3.2 mm, 5 mm and 7.5 mm with a p value = 0.007 at a significance level of 95%.

Table 3. Mean Rank of Each A Slice Thickness Size

Images	Mean Rank
A (3.2 mm)	3.00
B (5 mm)	2.00
C (7.5 mm)	1.00

Based on the table regarding the mean rank, it can be seen that the mean rank of the quality of paranasal sinuses CT Scan images in sinusitis case with a slice thickness of 3.2 mm was 3.00, for slice thickness of 5 mm it was 2.00 and for slice thickness of 7.5 mm it was 1.00. Such finding indicated that the highest mean rank was for slice thickness of 3.2 mm, followed by slice thickness of 5 mm and slice thickness of 7.5 mm.

To find out the difference between 2 groups of slice thickness sizes, a comparison test between one group and another group was carried out using the Wilcoxon signed-rank statistical test.

Table 4. Wilcoxon Signed Ranks Test Results

Group	Negative anks	Positive ranks	Ties	p value
Slice thickness 5 – 3.2 mm	5	0	0	0.042
Slice thickness 7.5 – 3.2 mm	5	0	0	0.043
Slice thickness 7.5 – 5 mm	5	0	0	0.043

Based on the test results, it was found that there was a significant difference in the quality of the paranasal sinuses CT Scan images in sinusitis case between the slice thickness of 3.2 mm and 5 mm with a p value = 0.042 (p<0.05). Furthermore, the mean

ISSN 2685-8673 (online)

rank value for the slice thickness of 3.2 mm was higher than the slice thickness of 5 mm, since the negative rank was higher than the positive rank. There was also a significant difference in the quality of the paranasal sinuses CT Scan images in sinusitis case between the slice thickness of 3.2 mm and 7.5 mm with a p value = 0.043 ($p<0.05$). The mean rank value for the slice thickness of 3.2 mm was higher than the slice thickness of 7 mm, since the negative rank was higher than the positive rank.

Based on the study data, it was shown that there was a significant difference in the quality of the paranasal sinuses CT Scan images in sinusitis case by slice thickness variations of 3.2 mm, 5 mm and 7.5 mm. In addition, among the three slice thickness variations, paranasal sinuses CT Scan sinus images in sinusitis case with the thinnest slice thickness of 3.2 mm showed the best image quality.

The difference in the quality of paranasal sinuses CT Scan images in sinusitis case was due to the effect of choosing a different slice thickness. Selection of different slice thickness will affect the spatial resolution, contrast resolution, noise and artifacts as the four components of CT Scan image quality. The thinner slice thickness will lead to an increase in the spatial resolution so that the ability of the paranasal sinuses CT Scan image to distinguish small objects with different densities on the same background will also increase.

According to Busberg (2012), a thin slice thickness will increase the sharpness of the edges of the structure on the CT Scan image so that the image looks more detailed. To increase the spatial resolution, a thinner slice thickness should be applied (Seeram, 2016). Therefore, the thinner the slice thickness, the higher the spatial resolution so as to improve the quality of the resulting paranasal sinus CT scan image.

The thinner the slice thickness will lead to a decrease in the contrast resolution so that the ability of the paranasal sinuses CT Scan image produced to distinguish an appearance of objects with very small density differences will also decrease. Slice thickness has a direct effect on the number of X-ray photons used to produce a CT scan image. The thinner the slice thickness, the smaller the number of X-ray photons used to produce a CT scan image, thus reducing the signal to noise ratio (SNR) and contrast resolution (Bushberg et al, 2012).

At the same kV and mAs settings, the number of detected X-ray photons increases linearly with the size of the slice thickness. For example, from a slice thickness of 5 mm to 10 mm (with the same kV and mAs), the number of X-ray photons detected will be doubled and the SNR (signal to noise ratio) will increase by 41%. Thus, a thicker slice thickness will increase the contrast resolution (higher SNR). For the use of thin slice thickness, mAs should be increased to compensate for the loss of X-ray photons due to collimation (Bushberg et al, 2012). Therefore, if the slice thickness is getting thinner, the contrast resolution will decrease and the quality of the resulting paranasal sinus CT scan image will decrease consequently.

The thinner the slice thickness, the higher the noise as well as the higher the fluctuation (standard deviation) of the CT number value in the resulting paranasal sinus CT scan image. According to Bushberg et al (2012), an increase in noise will affect the resolution contrast. A higher noise will lead to a decerease in the resolution contrast. Therefore, a thinner slice thickness will lead to an increase in noise so that it will further decrease the quality of the resulting paranasal sinus CT Scan image.

ISSN 2685-8673 (online)

Partial volume artifact occurs when tissues of widely different absorption are encompassed on the same CT voxel producing a beam attenuation proportional to the average value of these tissues (Murphy, 2020). The thinner the slice thickness will result in reduced artifacts so that the possibility of image errors that are not related to the object in the resulting paranasal sinuses CT Scan image can also be decreased.

According to Seeram (2016), the thinner slice thickness will minimize the contradiction/difference between the reconstructed CT number in the image and the actual attenuation coefficient of the object being examined. A thinner slice thickness will reduce the occurrence of partial volume artifact on the CT scan images regarding the slices of an object at the thickness of the object. If there are two or more different densities in one slice, then the image is a representation of the thickness of the object. the slice (Bushberg et al, 2012; Seeram, 2016). Therefore, if a thinner slice thickness will result in a decreased partial volume artifact so that it will improve the quality of the resulting paranasal sinus CT scan image.

Setting a thin slice thickness parameter in the paranasal sinuses CT Scan examination may increase noise and decrease the contrast resolution so that the quality of the resulting paranasal sinuses CT Scan image will decrease. However, this outcome can be corrected by a decrease in the partial volume artifact and an increase in spatial resolution. Therefore, the paranasal sinuses CT Scan image in sinusitis case with the thinnest slice thickness of 3.2 mm showed the best quality. The thinnest slice thickness setting on the paranasal sinuses CT Scan that produces the best image quality will result in a more accurate assessment of sinusitis disease by radiologist.

CONCLUSION

There was a significant difference in the quality of paranasal sinuses CT Scan image in sinusitis case by slice thickness variations with a p value = 0.007 ($p<0.05$). Among the three variations in the size of the slice thickness, namely 3.2 mm, 5 mm and 7.5 mm, the paranasal sinuses CT Scan image in sinusitis case with the thinnest slice thickness size of 3.2 showed the best image quality with the mean value of the highest rank of 3.00.

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ISSN 2685-8673 (online)