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The Effect of Slice Thickness Variation on The Anatomical Information of CT Scan Paranasal Sinus Coronal Section in Clinical Rhinosinusitis

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ABSTRACT

CT Scan is an excellent technique in assessing anatomical structures, anatomical abnormalities, and visualising the presence or absence of pathological tissue in the four sinuses and their extensions. One of the important parameters on CT Scan is slice thickness. Slice thickness is a thickness of the slice that can be adjusted according to clinical requirements with a variation of values from 1 to 10 mm. The purpose of this study is to determine the effect of slice thickness variation on anatomical information of CT Scan paranasal sinus coronal section in rhinosinusitis and slice thickness variation that produces the most optimal anatomical information. This study is an analytical quantitative study with an experimental approach conducted on 10 samples who performed CT scan examination of paranasal sinus in rhinosinusitis using slice thickness variations of 0.6 mm, 1 mm, 1.5 mm and 2 mm. Based on the results of Friedman test and Wilcoxon Post Hoc test, the p value is 0.0001 ($p<0.05$) which means there is an effect of using slice thickness variation on anatomical information. The mean rank value in the Friedman test for slice thickness variations of 0.6 mm is 3.70, 1 mm is 3.13, 1.5 mm is 1.85, and 2 mm is 1.32 so based on the test results, slice thickness variation that shows the most optimal anatomical information is 0.6 mm.

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1. INTRODUCTION

One of the body organs whose shape varies in each individual is paranasal sinus. The paranasal sinus are cavities in the bones that result from pneumatization of the bones of the head. There are four pairs of paranasal sinus, namely the frontal sinus, ethmoid sinus, right and left sphenoid sinus and maxillary sinus [1]. Health in the paranasal sinus is strongly influenced by the patency of the sinus ostium and the smooth mucociliary clearance in the osteomeatal complex (KOM) [2]. The osteomeatal complex (KOM) has an important role for mucus and debris transport, preventing bacterial growth by maintaining oxygen pressure and as a drainage site for the anterior sinus, namely the frontal sinus, anterior ethmoid sinus, and maxillary sinus [3]. The disruption of drainage in the patency of the osteomeatal complex (KOM) is one of the main causes of rhinosinusitis [4].

The term rhinosinusitis is more commonly used to describe the conditions of sinusitis and rhinitis. Sinusitis is a term that refers to the condition of sinus inflammation, while rhinitis is an inflammation that occurs in the mucous membrane or mucous membrane of the nose. The close location and similarity of epithelial structures cause rhinitis conditions to occur simultaneously with sinusitis [5]. Clinically, rhinosinusitis is an inflammatory condition of the nasal mucosa and paranasal sinus accompanied by fluid formation. According to the American Academy of Otolaryngic Allergy (AAOA) and American Rhinologic Sociaty (ARS), rhinosinusitis is classified into acute rhinosinusitis (RSA), recurrent acute rhinosinusitis, sub acute rhinosinusitis (RSSA), chronic rhinosinusitis (RSK) and chronic rhinosinusitis with acute exacerbation. Acute tract infection is still a major disease in Indonesia [6]. According to the Ministry of Health of the Republic of Indonesia in 2003, out of 50 major diseases, nasal and sinus diseases ranked 25th with 102,817 hospital outpatients [7]. In 2022, CT scan examination of the paranasal sinuses with clinical rhinosinusitis in one of the private hospitals in Denpasar was around 22 people.

Treatment of various pathologies of the nose and paranasal sinuses is greatly influenced by the imaging technology used. Imaging technologies such as Computed Tomography play an important role in analyzing the paranasal sinuses with better accuracy than conventional radiography. Computed Tomography has developed rapidly since CT images were first obtained in the late 1970s [8]. CT Scan is a diagnostic radiology tool with a tomography method that produces digital images in the form of individual sheets of patient body tissue. Images on a CT Scan are obtained by transmitting x-rays to the patient's body from various angles, rotating the x-ray tube around the patient's body, then captured and collected using a series of detectors. A series of numerical data from the detectors are then reconstructed to obtain a tomographic field image of the object (patient) being examined [9].

CT Scan is an excellent technique in assessing anatomical structures, because it is able to show the anatomical structure of the nose and paranasal sinuses such as the osteomeatal complex (KOM), abnormalities in anatomy, and visualization of the presence or absence of pathological tissue in the four sinuses and their extensions [10]. CT Scan of the paranasal sinus in sinusitis cases is used to see the obstruction of the osteomeatal complex (KOM), while in chronic rhinosinusitis cases, it is used to see the expansion of the sphenoid sinus to the posterior nasal septum, agger nasi cell (ANC), and nasal septal deviation [5]. The coronal section on CT scan paranasal sinus is the best sections for evaluation of the osteomeatal complex, while the axial sections helps in identifying the basal lamina of the middle turbine that separates the anterior and posterior ethmoid sinus. Coronal section are more informative than axial section as they can identify anatomical changes and better visualize the sinus and adjacent structures [11], [12].

Appropriate anatomical features and high diagnostic accuracy should be reflected in the quality of radiology images. One of the important parameters in image quality is slice thickness. Slice thickness is a thickness of the slice that can be adjusted according to clinical requirements with a variation of values from 1 to 10 mm [5]. CT scan examination with a thin slice thickness is used on small organs, while on organs that have a large size, a thick slice thickness can be used [13]. The thicker slice thickness value, the larger the voxel size will be and will increase contrast resolution but will decrease spatial resolution and noise. The thinner slice thickness used, the smaller the voxel size will be, thus reducing contrast resolution but increasing spatial resolution and noise [5].

The slice thickness used in CT Scan paranasal sinus according to Sigit Wijokongko (2016) in axial section is 2-3 mm and for sagittal and coronal section is 1.5-2 mm [14]. Whereas in research conducted by Kastiwi (2022), it was found that the most optimal use of slice thickness reconstruction was 1 mm with 0.5 mm increament reconstruction [15]. While in other references that the author found, the slice thickness used was different, namely 0.625 mm [16]. In the Radiology Unit of a private hospital in Denpasar, CT scan examination of the paranasal sinus is performed using slice thickness of 2 mm.

Based on this background, the author is interested in examining and analyzing the use of slice thickness variations on the anatomical information of the paranasal sinus, osteomeatal complex, and mucosal thickening on CT Scan examination of the paranasal sinus in coronal section. The purpose of this study is to determine the effect of slice thickness variation on the anatomical information of CT Scan paranasal sinus coronal section using slice thickness reconstruction of 0.6 mm, 1 mm, 1.5 mm and 2 mm and to determine the slice thickness variation that produces the most optimal anatomical information on CT Scan of paranasal sinus in rhinosinusitis.

2. METHOD

This type of research is an analytical quantitative research with an experimental approach to analyze the effect of slice thickness variation on anatomical information of CT Scan paranasal sinus coronal section with clinical rhinosinusitis, which was conducted from April to May 2023. The samples in this study were 10 patients of male and female with an age range of 17-70 years who performed CT scan examination of the paranasal sinus in rhinosinusitis. The number of samples in this study was taken using the Lemeshow formula.The research was conducted by opening 10 raw data of patients who performed CT scan examination of paranasal sinus, then reconstructing the image of the paranasal sinus coronal section with slice thickness variations of 0.6 mm, 1 mm, 1.5 mm and 2 mm with controlled increament reconstruction of 0.5 mm. The images will be transferred to a compact disc (CD-R) and stored in a laptop using the Radiant Dicom Viewer application with DICOM format. Then, three radiologists were requested to assess the anatomical information (paranasal sinus, osteomeatal complex and mucosal thickening) on the CT scan image of the paranasal sinus by giving a questionnaire. Radiology specialists as respondents will conduct an assessment using the assessment form. In this assessment, respondents ticked (√) on the questionnaire form provided, with the criteria for each image including:

Score 1 = less clear (the object of the evaluated image is seen with less firm boundaries and the smallest part of the object is not clearly visible).
Score 2 = fairly clear (the object of the evaluated image is visible with fairly firm boundaries but the smallest part of the object is not clearly visible).
Score 3 = clear (the objects of the evaluated image are visible with well-defined boundaries but the smallest parts of the objects are not clearly visible).
Score 4 = very clear (the object of the evaluated image is visible with a firm boundary up to the smallest part of the object).

Furthermore, testing was carried out using the SPSS application. Data from respondents in the form of ordinal data was then collected and analysed using the SPSS version 25.0 program. The Interclass Correlation Coefficient test was conducted to determine the level of agreement. Since the data obtained is ordinal data and has a variation of > 2 groups of variables, the Friedman test is used. Then to further determine the difference between variables (which one is influential) continued with the Wilcoxon Post Hoc test. The results of the Friedman test and the Wilcoxon Post Hoc test will produce a probability value (p) which means the significant value of the difference. The mean rank value in the Friedman test is used to determine the slice thickness variation that displays the most optimal anatomical information.

3. RESULTS AND DISCUSSION

Table 1. Sample Characteristics Based on Gender and Age

Gender	Total	Percentage
Male	6	60%
Female	4	40%
Total	10	100%

Age	Total	Percentage
17-40	7	70%
41-70	3	30%
Total	10	100%

Table 1 above shows that the sample in this study amounted to 10 patients, with 6 male patients (60%) and 4 female patients (40%) with an age range of 17-40 years as many as 7 people (70%) and an age range of 41-70 years as many as 3 people (30%).

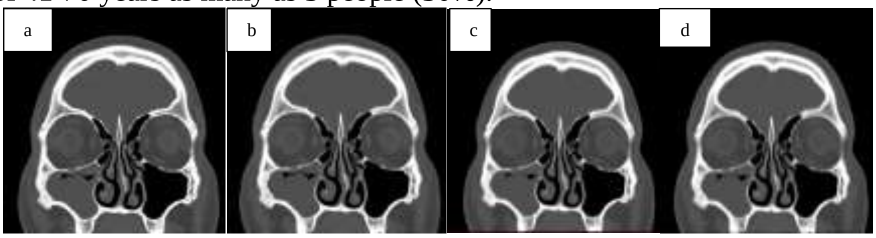

Figure 1. Results of CT Scan Images of Paranasal Sinuses Coronal Section With Slice Thickness Variation of (a) 0.6 mm, (b) 1 mm, (c) 1.5 mm and (d) 2 mm

Table 2. Interclass Correlation Coefficient Test Results

Slice Thickness Variation	Interclass Correlation Coefficient R1 x R2 x R3	Description
0.6 mm, 1 mm, 1.5 mm, 2 mm	0.912	Very Good

The results of the Interclass Correlation Coefficient test between 3 respondents obtained a value of 0.912 which means that there is a very good agreement or similarity of perceptions, so that to carry out the Friedman test and the Wilcoxon Post Hoc test, the results of the assessment from respondent 1, with a longer work experience than the other respondents, namely 10 years, will be used.

Table 3. Friedman Test Results on Slice Thickness Variations on Overall Anatomical Information

Variable	P Value	Meaning
Slice Thickness 0.6 mm Slice Thickness 1 mm Slice Thickness 1.5 mm Slice Thickness 2 mm	0.0001 (p value<0.05)	Ho rejected

Friedman test results obtained p value 0.0001 (p <0.05) then Ho is rejected and Ha is accepted, which means there is an effect of using slice thickness variations.

Table 4. Friedman Test Results on Each Anatomical Criteria

Anatomy	Slice Thickness Variation	P Value	Meaning
Paranasal Sinuses Osteomeatal Complex Mucosal Thickening	0.6 mm, 1 mm, 1.5 mm, 2 mm	0.0001 (p *value*<0.05)	Ho rejcted

From the results of the Friedman test on each anatomical criterion with p value is 0.0001 (p < 0.05), Ho is rejected and Ha is accepted, which means that there is an effect of using slice thickness variations on the paranasal sinuses, osteomeatal complex, and mucosal thickening.

Table 5. Wilcoxon Post Hoc Test between Slice Thickness Variations

Variable	P *Value*	Meaning
Slice Thickness 0.6 mm-*Slice Thickness* 1 mm *Slice Thickness* 0.6 mm-*Slice Thickness* 1.5 mm *Slice Thickness* 0.6 mm-*Slice Thickness* 2 mm *Slice Thickness* 1 mm-*Slice Thickness* 1.5 mm *Slice Thickness* 1 mm-*Slice Thickness* 2 mm *Slice Thickness* 1.5 mm-*Slice Thickness* 2 mm	0.0001 (p *value*<0.05)	Ho rejected

From the results of the Wilcoxon Post Hoc test between slice thickness variations, the p value is 0.0001 (p <0.05), so Ho is rejected and Ha is accepted, which means there is a difference between slice thickness variations.

Table 6. Mean Rank Value in Friedman Test

Slice Thickness Variation	Mean Rank
0.6 mm	3.70
1 mm	3.13
1.5 mm	1.85
2 mm	1.32

Table 6 shows that the mean rank value for the slice thickness variation of 0.6 mm is 3.70, 1 mm is 3.13, 1.5 mm is 1.85, and 2 mm is 1.32. So it can be concluded that the slice thickness variation that displays the most optimal anatomical information is 0.6 mm.

Discussion

Slice thickness is the thickness of the slice that can be adjusted according to clinical requirements with a variety of values from 1 to 10 mm [5]. According to Sigit Wijokongko (2016), the slice thickness used in the CT scan of the paranasal sinus in the coronal section is 1.5-2 mm [14], The study conducted by Kastiwi (2022) found that the most optimal use of reconstruction slice thickness is 1 mm [15], and according to other references the slice thickness used is 0.625 [16]. Based on this, 4 variations of slice thickness (0.6 mm, 1 mm, 1.5 mm and 2 mm) were used in this study. CT scan examination with a thin slice thickness is used on small organs, while on organs that have a large size, a thick slice thickness can be used [13]. The thinner slice thickness, the more image information is generated and the more detailed, but the noise will be higher, so that anatomical information can be displayed clearly [17]. A thin slice thickness will make the image appear more detailed, because the sharpness of the edge of the structure in the CT scan image increases [18], where a thin slice thickness (0.6 mm) provides better detail than a thick slice thickness (2 mm). The results of these studies can be assessed visually, which is significantly different. To obtain more valid anatomical information, an assessment was made by a Radiology specialist as the respondent in this study.

The results of the questionnaire assessment by Radiology specialists will be analyzed using the SPSS application, namely the Friedman test, where the p value 0.0001 ($p < 0.05$) is obtained, which means there is an effect of using slice thickness variations on the anatomical information of CT Scan paranasal sinuses coronal section in clinical rhinosinusitis. The selection of slice thickness in CT scan examination will affect the anatomical information produced, where slice thickness contributes as much as 39.4% to the quality of anatomical images [19]. The thinner slice thickness, the better the quality, which will increase spatial resolution and improve the ability to distinguish small objects with different densities in the same background [13], [18]. The slice thickness of 0.6 mm is the smallest configuration on the CT scanner at the research hospital, which is able to display anatomical information with better resolution. This has been shown from the Friedman test results.

The thicker the slice thickness value, the larger the voxel size will be and will increase contrast resolution but will decrease spatial resolution and noise. The thinner the slice thickness used, the smaller the voxel size will be, the contrast resolution will decrease but can increase spatial resolution and noise [5]. Noise caused by the use of thin slice thickness can be reduced by reconstructing the smooth algorithm which is the standard kernel for low density organs such as the paranasal sinus [20]. Based on Table 6, the slice thickness variation of 0.6 mm has the highest mean rank value of 3.70. These results indicate that the use of 0.6 mm slice thickness variation is able to visualize antomic information, namely the paranasal sinus, osteomeatal complex, and mucosal thickening the most optimal in clinical rhinosinusitis. In small pathologies or organs, and examinations that require coronal or sagittal reconstruction, it is necessary to use a thin slice thickness, so that the image will look smoother [13], [21]. Thick slice thickness is less effective in showing sinonasal obstruction, especially in patients with clinical rhinosinusitis [22].

The selection of a thinner slice thickness will result in a greater number of slices [21], so as to reveal more detailed anatomical information, which is expected to add information on small organs to Radiology specialists when performing exams. This is in line with the theory, where the thinner the slice thickness, the more image information is generated and the more detailed, but the noise will be higher, so that anatomical information can be displayed clearly [17]. The study has limitations due to the small size of the sample and the limited duration of the research.

4. CONCLUSION

There is an effect of using slice thickness variations of 0.6 mm, 1 mm, 1.5 mm and 2 mm on the anatomical information of CT scan paranasal sinus coronal sections in clinical rhinosinusitis, which thinner slices thickness result in better quality and will increase the spatial resolution and improve the ability to distinguish small objects with different densities in the same background. Slice thickness variation of 0.6 mm is able to visualize the most optimal anatomical information in clinical rhinosinusitis because of the highest mean rank value and able to provides better detail than a thick slice thickness (2 mm) which is expected to add information on small organs to radiologists when performing examinations.

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