ORIGINAL ARTICLE

An Analysis of Anatomy Image Information on Slice Thickness Variation in Orbital CT Scan Examination

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ABSTRACT

Background: In contrast to the literature, orbital CT scans at the hospital used a 1.25 mm thick slice, then reconstructed with a slice thickness according to the clinical setting.
Aim: This research aimed to determine the anatomical image of orbital CT scan in slice thickness variations and determine the value of slice thickness, which produced optimal anatomical image information.
Method: It was experimental research. There were 15 patients with orbital CT scans whose slice thickness was made into a 1.25 mm data row. The data row was then reconstructed with slice thickness variations into 1.25 mm, 2 mm, 2.5 mm, 3 mm, 4 mm, and 5 mm. Information clarity about anatomical imagery was assessed, including Nasal Bone, Optic Nerve, Sinus Ethmoidalis, Sinus Sphenoidalis, Lacrimal Bone, Cornea, Lens, Globe, and Sclera. Data analysis with Spearman test and Friedman test showed α = 5%.
Results: There is a difference in information on anatomical images of orbital CT scan in Slice thickness variations with p-value <0.023. 2.5 mm slice thickness results in the most optimal anatomical image information with mean rank = 5.50. Slice thick 3 mm can be used as an alternative to getting the same anatomical image information with a smaller radiation dose.
Keywords: Anatomical Image Information, Slice Thickness, CT ScanOrbita

INTRODUCTION

CT scan is a diagnostic modality that helps in diagnosing. CT scans can evaluate various pathologies quickly and are sensitive in assessing pathology, especially in soft tissues. Orbital CT scan is one of the CT scan examinations that are quite often encountered. It can describe the accuracy of the orbital bone structures[1]. Routine inspection for orbits is done in two ways: axial scanning and coronal scanning; the slice thickness is not more than 2 mm[2]. A thin slice (3 mm) is preferred to describe the orbit's axial scanning and coronal scanning. Slice thickness can be between 1 mm - 10 mm according to clinical requirements. Based on the clinical condition, the slice thickness of tumors used is 3-5 mm[3]. Several stages form images CT scans, such as data acquisition, image reconstruction, and image display. Data acquisition is retrieving data from the patient and captured by the detector to obtain profile intensity. The capture is then converted into an image. The raw data then reconstructed with the kernel filter and back-projection into the image matrix [3]. The image matrix consists of a picture element or pixel. A pixel is an essential element of a two-dimensional digital image. Every pixel on the image in the CT scan is related to voxel[3]. Voxel has the same dimension as pixels but with slice thickness. Each pixel on the CT scan image displays X-ray's average attenuation from the network in one voxel [5]. Voxel size is influenced only by slice thickness, matrix size, and FOV. The relationship between voxel size and slice thickness, matrix, and FOV can be seen in the following equation [4][5] :

$$Voxel\ Size\ = \frac{FOV\ x\ Slice\ thickness}{Matriks\ Size} \qquad (1)$$

A thick slice will produce a low detail image, while a thin piece will pay a high detail image [3]. A thick slice increases the likelihood of losing small objects. If the scanned area is a suspected mass image but has not been identified, choosing a thinner piece is strongly recommended[6][7]. In some hospitals, CT scans for orbital tumors are performed using 1.25 mm slice thickness, and reconstruction will be carried out with various slice thicknesses according to clinical needs. The research was to find out the anatomical image of orbital CT scan in different slice thickness and thickness slice values that produced optimal anatomical imagery of orbital CT scans.

METHODS

It was experimental research. Axial scanning from 15 orbital CT scan patients was made with a data row of 1.25 mm slice thickness, with an exposure factor of 130 kV and 150 mAS. The scanning results were then reconstructed with slice thickness variations, which are 1.25 mm, 2 mm, 2.5 mm, 3 mm, 4 mm, and 5 mm. Data in the form of orbital CT anatomy image clarity information was assessed by two radiologists using a checklist with an ordinal scale. Assessment of information clarity of anatomical images including Nasal Bone, Optic Nerve, Sinus Ethmoidalis, Sinus Sphenoidalis, Lacrimal Bone, Cornea, Lens, Globe and Sclera (Ethel, 2004). The data were analyzed using the Spearman test, the Friedman test, followed by the Wilcoxon test with an error margin of (α) = 5%.

RESULTS AND DISCUSSION

The result of initial scanning with 1.25 mm slice thickness and after reconstruction with some slice thickness variation of 15 patients of orbital CT involved in this study resulted in orbital CT images, as shown in Figure 1

The validity test results between two respondents show the appropriateness of assessment between respondent one and respondent 2 with a kappa coefficient of 0.874 and p-value <0.001. To determine the relationship between information on anatomical images of orbital CT scan andslicethicknessvariations, a statistical test was performed by Spearman test. The results ofSpearmantestwith slice thickness variation of 1.25 mm, 2 mm, 2.5 mm, 3 mm, 4 mm, and 5 mm are shown in table 2:

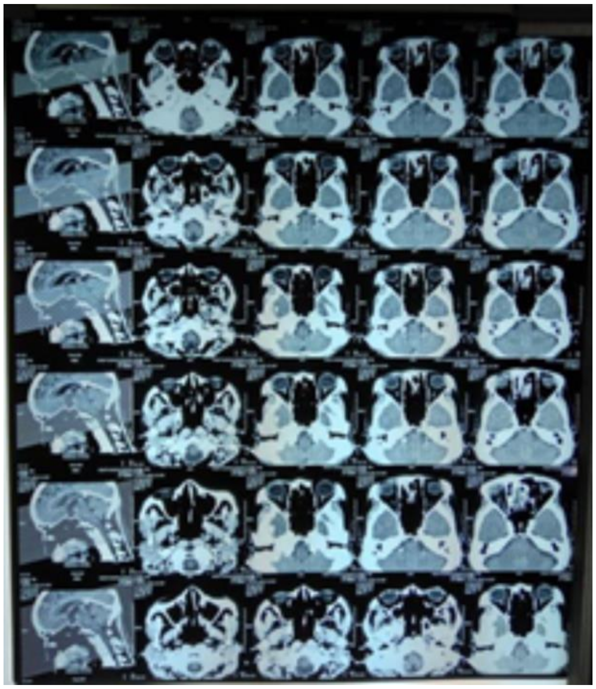

Figure 1. Image of orbital CT scan with slice thickness variations

a. Orbital CT image using 1.25 mm slice thickness
b. Orbital CT image using2 mm slice thickness
c. Orbital CT image using2.5 mm slice thickness
d. Orbital CT image using3 mm slice thickness
e. Orbital CT image using4 mm slice thickness
f. Orbital CT image using5 mm slice thickness

The results from the two radiologists were tested by the respondent's validity assessment using the Kappa test, as shown in table 1.

Table 1. Validity Test between Respondent

Respondents	**Korff Kappa**	**p-value**
R-1 vs R-2	0.874	<0.001

Table 2. The test results of the relationship between slice thicknesses and anatomical information images on orbital CT scan

Variable	**r**	**R**	**p-value**
Slice thickness - Information Anatomical image of CT scan of orbital	- 0.662	0.3944	<0.001

The test shows a strong relationship between slice thickness variation and anatomical image information on orbital CT scan, with correlation coefficient r = -0.662 and p-value <0.001. The correlation coefficient's negative values indicate a strong relationship between slice thickness and anatomical information, but the relationship is not in the same direction. The thicker the slice, the lower the quality of the anatomical image of the orbital CT scans. The determination coefficient of R = r2 = 0.3944 shows that slice thickness factors influence the anatomical information clarity of 39.44% while other factors influence the remaining 60.56%. A different test is the Friedman test used to determine the difference in information on anatomical orbital CT scan images shown in table 3.

Table 3.Friedman test of anatomical image CT orbital scan images in slice thickness variations

Slice thickness Variations	p-value	Mean Rank
1.25 mm	0.023	3.90
2.00 mm		4.30
2.50 mm		5.50
3.00 mm		4.00
4.00 mm		2.20
5.00 mm		1.10

The test results show differences in information on anatomical images of orbital CT scan examination on slice thickness variation with p-value = 0.023. The mean rank value shows the slice thickness with the best anatomical image information on the orbital CT scan. Table 3 shows that from the six slice thickness variations, the2.5 mm slice thickness produces the best orbitals CT scan information on anatomical images with the highest mean rank value of 5.50. To find out the differences in anatomical information, the Wilcoxon test was shown in table 4.

Table 4. Wilcoxon rank test on the results of anatomical image information on orbitals CT scan

Difference between Slice Thickness (ST)	**p-value**
ST 2.0 mm vs. ST 1.25 mm	0.049
ST 2.5 mm vs. ST 1.25 mm	0.033
ST 3.0 mm vs. ST 1.25 mm	0.036
ST 4.0 mm vs. ST 1.25 mm	0.029
ST 5.0 mm vs. ST 1.25 mm	0.027
ST 2.5 mm vs. ST 2.0 mm	0.091
ST 3.0 mm vs ST 2.0 mm	0.043
ST 4.0 mm vs. ST 2.0 mm	0.019
ST 5.0 mm vs. ST 2.0 mm	0.028
ST 3.0 mm vs. ST 2.5 mm	0.078
ST 4.0 mm vs. ST 2.5 mm	0.043
ST 5.0 mm vs. ST 2.5 mm	0.032
ST 4.0 mm vs. ST 3.0 mm	0.048
ST 5.0 mm vs. ST 3.0 mm	0.025
ST 5.0 mm vs. ST 4.0 mm	0.035

The Wilcoxon rank test showed no difference in anatomical information between 2.5 mm and 2 mm (p-value = 0.091) slice thickness and between2.5 mm and 3 mm slice thickness (p-value = 0.078). From the Wilcoxon-test results, 2 mm and 3 mm slice thickness can be used as an alternative of slice thickness on CT scan.

DISCUSSION

The choice of slice thickness in CT Scan examination will affect the information on anatomical images[6][7]. Slice thickness contributes 39.4% to the quality of anatomical illustrations. Slice thickness will affect spatial resolution, contrast resolution, noise, and artifacts. These four aspects are components of CT Scan image quality so that changes in these four aspects will determine the quality of anatomical image[8][9]. The choice of the thicker slice, the voxel size will be more excellent so that the contrast resolution will increase, the spatial resolution will decrease, and noise will reduce[5].

Conversely, if the slice is thinner, the voxel size is reduced so that the spatial resolution and noise will increase while the contrast resolution will decrease[6]. A thin slice will increase the edge sharpness of the CT Scan image structure so that the image looks more detailed [2]. To improve spatial resolution, a thinner slice should be used. The contrast resolution will decrease if the piece is more delicate. The anatomical image of the orbital CT scan to distinguish an object with a minimal density difference will also reduce. The use of smaller slices produces increasing fluctuations (standard deviations) of the CT value created so that the orbital CT scan image's noise will also increase [2]. The increasing noise will affect the contrast resolution. The higher noise will cause the contrast resolution to decrease. The use of a thinner slice will also reduce partial volume artifact[3][4]. The results of this research are in line with Syofwanawatie's study [9].

The use of thicker slice thickness will produce disturbing images such as lines, and if this line is too thin, the picture will not look smooth[9]. A slice thickness that can make optimum information on the orbital CT scan's anatomical image is 2.5 mm slice thickness. The 2.5 mm slice thickness can produce noise and optimum spatial resolution on orbital CT scan images. The use of 2.5 mm slice thickness can show objects that require high spatial resolution and optimal noise in all orbital CT scan image objects, including microscopic anatomy that requires excellent detail as in Indrati's study[10]. The influence of slice thickness on spatial resolution, contrast resolution, noise, and artifact can be seen in the determination coefficient. The determination coefficient shows that 39.44% of the quality of orbital CT Scan anatomy images is determined by slice thickness, while other factors determine 60.56%. The other factors that influence the quality of the orbital CT Scan anatomical image are exposures factor, geometric factors, FOV, range, matrix reconstruction, algorithm, Window Width, Window Level, filter/kernel, and subject factors.

CONCLUSION

There is a correlation between anatomical image information with the slice thickness of orbital CT scan through statistical spearman test with p <0.001. Slice thickness which can provide optimal anatomical image information on orbital CT scan is 2.5 mm slice thickness with mean rank test 5.50. 3 mm slice thickness can be used as an alternative in the orbital CT Scan if the patient's radiation dose is smaller.

REFERENCES

[1] K. L. Bontrager, "No Title," Text B. Radiogr. Position. Relat. Anatomy., 2001.

[2] Springer, "No Title," in Computed Tomography State of the Art and Future Applications., Berlin Heidelberg NewYork, 2008.

[3] E. Seeram, "No Title," in Computed Tomography Physical Principles, Clinical Applications, and Quality Control. Second Edition, 2001.

[4] B. J. M. Bushberg Jerrold T, Seibert J. Anthony, Edwin M. Leidholdt Jr., "No Title," in The Essential Physics of Medical Imaging, North Amer., 2003.

[5] Bushong, "No Title," Radiat. Prot. Radiobiol., 2002.

[6] Brooker MJ, "No Title," Comput. Tomogr. Radiogr. MTP Press Ltd. Engl. Eur. Guildnes MSCT, 2012.

[7] Lois E Romans, "No Title," in Introduction to Computed Tomography, 2nd edition, Williams & Wilkins, Williams &., England, 2001.

[8] Naseth R, “No Title,” in Procedure and Documentation for CT and MRI, CIC Edizio., 2000.

[9] S. Ethel, "No Title," in Anatomy and Physiology for Beginners, Mold 1, Jakarta: EGC, 2004.

[10] R. Indrati, "No Title," Differ. Qual. Parana. Sinus CT Scan Images Using Thick. Slice Var. Sinusitis Cases Radiol. Install. Telegorejo Hosp. Semarang, 2008.