The Optimization of Mastoid CT Image Using Windows and Kernel Reconstructions

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Abstract CT scan can be used to show the anatomical and pathological evaluation of Mastoid bones where an X-ray across it to create a cross-sectional image with an advanced computer. This imaging modality allows the radiologist to look at different levels of the bone ridge behind the ear. In our hospital, this procedure needs to be improved. Radiographer could make optimization by adjusting windows and developing kernel to maintain the image quality. This study aimed to obtain the optimum image of Mastoid bones, using variations of window and kernel reconstruction. The study was descriptive quantitative with an experimental approach. It resulted in eight images of two windowing levels (sinus and inner ear) and four kernel variations (smooth, medium, sharp, and ultra-sharp). Three radiologists evaluated the injury, bleeding, and soft tissue abnormalities images. The result showed that all window settings are acceptable. Kernel reconstructions have no different anatomical image information in soft tissue, Internal Auditory Canal, and External Auditory Canal. There is a difference for overall anatomical information of Mastoid bones (p value<0.05). Highest values of mean rank are obtained from sharp and ultra-sharp. Our recommendations are using the H.20s smooth kernel for soft tissue abnormalities and H.70s sharp kernel for fracture and bleeding cases.

1. Introduction

Mastoid air cells are open spaces that contain air all over the mastoid bone. The protruding bulge located behind the ear is part of the temporal bone of the skull. Mastoid air cells are considered essential to the physiology of the function of the middle ear, functioning as air dams and functioning as a buffer system to replace the air in the middle ear [1]. Multi-Slice Computed Tomography (MSCT) is one of the diagnostic radiology examination tools that utilize computers to reconstruct the data obtained. A detector is a tool that works to capture X-ray files that have penetrated an object for data and are forwarded to the computer as numerical data, and then the computer converts data into analog data which can be viewed as an image [2]. Through the development of CT scan techniques, CT scans are now the diagnostic imaging of choice for temporal bone imaging [3]. CT Scan application for medical purposes should be ensured that the image quality obtained should be good with relatively low doses. Image quality is characterized by several parameters, including low noise and high spatial resolution. For that is usually done in accordance with the optimization of clinical applications used, namely relatively low noise with relatively high spatial resolution. For bone, high spatial resolution is usually selected, while for the soft tissue, low noise is selected. Another thing that can be done is to develop noise reduction algorithms by maintaining spatial resolution, so the image quality remains good [4]. The selection of variations in algorithm/filter reconstruction will affect spatial resolution and
noise [5]. The hybrid convolution kernel is a promising technique affording optimized bone, soft tissue evaluation while potentially halving the number of images needed to be transmitted, stored, and reviewed [6].

The reconstruction kernel, which is also referred to as a filter or algorithm by some CT manufacturers, is one of the most important parameters affecting image quality. The choice of reconstruction is based on specific clinical applications. For example, a smooth kernel is usually used on brain or tumor assessment to reduce noise and increase low-contrast detection. On the other hand, the sharp kernel is commonly used in tests to assess bone structure due to the clinical needs of better spatial resolution. The H40 kernel used for soft tissue image on the head. To obtain a smoother image, the H30s or H10s kernel is used, for a sharper used with kernel H50s. The higher the kernel value (H.70s or H.90s), the higher the use of reconstruction algorithms the sharper the images [7].

This study aims to determine the difference in the quality of anatomical image information on the variations of window and kernel reconstruction and to know the best reconstruction variations to display anatomical information.

2. Method

The type of research was descriptive quantitative with an experimental approach. Research framework can be seen in fig.1. The researchers performed post-processing reconstruction of a raw data acquisition from every eight 8 patients of samples into the H.20s Smooth, H.40s Medium, H.70s Sharp, H.90s Ultra sharp kernels in the Sinus window and Inner Ear window. Then three radiologist doctors performed an image assessment, and analyzed the results using the Friedman test. To know the variation of window and kernel in yielding optimal anatomical information, the highest mean rank and highest respondent rating are recorded. The procedures in this study are:

2.1 Patient Examination Procedure

No special preparation. The patient is instructed to release objects that may interfere with the CT scan. The patient is instructed not to move or to move his head during the examination.

2.2 Mastoid CT Scan Imaging Procedure

Mastoid CT scan in patients was performed with the routine protocol in RSUD dr. Soediran Mangun Sumarso. The Raw Data results were reconstructed with a sinus window and Inner Ear Window with variation kernel of H.20s Smooth, H.40s Medium, H.70s Sharp, H.90s UltraSharp in both windows.

2.3 Implementation Procedure Image

The radiograph was evaluated by radiologists, in the clarity of anatomical information of the organ (Margins of Mastoid Air Cells (MAC), Ossicles (OS), Canalis Auditory Interna (CAI), Canalis Auditory Eksterna (CAE), Canalis Semi-Circular (CSC), and Cochlear (CHL)). The grading is score 1: not clear, score 2: less clear, and score 3: clear.

| Variation of kernel ini Window sinus and window Inner Ear |
|----------------------------------------------------------|
| 1. Kernel H.20s Smooth                                   |
| 2. Kernel H.40s Medium                                   |
| 3. Kernel H.70s Sharp                                    |
| 4. Kernel H.90s UltraSharp                               |

The clarity of anatomical information of the organ of mastoid CT-scan

Control variable:
1. Patient
2. Exposure Faktor
3. Scan Time
4. Slice thickness
5. Window Width
6. Window Level
3. Result
The study was conducted on eight patients under Mastoid CT examination with age range of 16-57 years, with a diagnosis of hearing loss. Each patient who examined has produced 20 slices of axial of Mastoid CT image then reconstructed by using a variation that is with kernel H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultrasharp in sinus window and Inner window Ear.

Fig. 2 shows axial CT Scan mastoid with Sinus window. The topmost image is the variation of the H.20s smooth kernel, the 2nd row is the H.40s Medium variant, the third line is the Sharp H.70s kernel, and the last line is the H. kernel. 90s Ultrasharp.
Fig. 3 shows axial CT Scan mastoid with Inner Ear window. The topmost image is with variations of H.20s smooth kernel, the second line is the use of H.40s Medium kernel, row 3 is Sharp H.70s kernel, and the last line is Ultra sharp H.90s kernel.

Based on Cohen's Kappa, the three respondents in assessing anatomical information have reached a special agreement, satisfactory and sufficient value of the test is >0.4. Therefore, it can be retrieved information from one of the respondent’s assessments of anatomical information results of the most experienced in their field. This test was taken from respondent 3 with more than 20 years of work experience.

The maximum value of the assessment of window and kernel variations is 423, while the maximum value of the organ rating is 559, with the minimum value of the rating being 114. From the above, it is known that the highest value of variation 423 is found in the H.90s Kernel in the sinus window. While the lowest value of 330 is on the reconstruction of the sinus window with the H.20s kernel.

It has also obtained information that the maximum value obtained each organ in each variation is 72. The maximum value of all reconstruction of the window and kernel of the three respondents is 576. Organs that get a maximum score of 559 is the organ of Canalis Auditory Interna, from the maximum score of 576 assessment on all reconstruction window and kernel H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultraspercent.

While the minimum value of assessment to three respondents on each organ is eight on every reconstruction, and value 192 on the overall reconstruction. For organs that get the lowest value of 330 is the organ of Margin of Mastoid Air Cells on H.20s reconstruction in the sinus window and Inner ear window. The Margin of Mastoid Organs Air Cells also gets the lowest score of 436 on the entire reconstruction variation. The significance level of the overall variation =0.0 (p<0.05) which means that there is a difference in image quality of anatomical image of CT Scan Mastoid on each variation of reconstruction.

Based on the Friedman test result, the significance of each Mastoid on each organ is = 0.0 (p<0.05) which means that there is a difference of information of the anatomical image of reconstruction kernel variation H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultrasharp in the sinus window and Inner
Ear window. Based on Margins of Mastoid Air Cells, Ossicles, Semi-Circular Canalis, and Cochlea on H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultra sharp variation in the sinus window and Inner Ear window. The significance value is 0.00, which means that there is a difference in anatomical image information of H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultra sharp variation in the sinus window and Inner Ear window.

However, on the organ of Canalis Auditory Interna and Canalis Auditory Externa, the significance value of variation of window and kernel H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultrasharp in sinus window and Inner Ear window is 0.29, which means that there is no difference of image information anatomical variation of kernel reconstruction H.20s Smooth, H.40s Medium, H.70 Sharp, H.90s Ultrasharp in the sinus window and Inner Ear window.

The result of the mean rank shows that the highest value of mean rank is obtained from the Canalis Internal Auditory and Canalis Auditory Externa with mean value 4.32, Canalis Semi-Circular with 3.28, Cochlea with 3.4, Margins Of Mastoid Air Cells with 2.98, and Ossicles with mean rank of 2.97.

4. Discussion

Canalis Auditory Interna and Canalis Auditory Externa for variations of reconstruction of Sinus and kernel have the same mean rank and Significance of window and kernel variations in the organ of Canalis Auditory Interna and Canalis Auditory Externa 0.429 which means that there is no difference between each variation of reconstruction. This is because originally Canalis Internal Auditory Externa is a soft tissue organ, this is in accordance this is in accordance with the research conducted by Seeram [8]. Smoothing algorithm to reduce image noise and show soft tissue anatomy well used in the examination where it is important to show soft tissue structure with very low contrast.

In the overall test of the Mastoid organ, based on each variation of the reconstruction of the window and kernel, the significance value of p is <0.05 which means that Ha is accepted, so it can be seen that there is a difference in the quality of anatomical information of CT Scan Mastoid reconstruction kernel H.20s Smooth, H.40s Medium, H.70s Sharp, and H.90s Ultrasharp in Sinus window and Inner Ear window.

According to the research conducted by You and Lung [7] mentioned that in order to get a smoother image, kernel H30s or H10s can be used, while for a sharper results, kernel H50s is used. The higher the kernel value (H.70s or H.90s), the sharper the image is higher the use of reconstruction algorithm (kernel) the sharper the image is. From the opinion of Leng and Siemens, information is obatained that to get the sharpness of anatomical information image CT Scan of Mastoid CT scan image it is better to use H.90s Ultrasharp kernel in the sinus window and this is evident from the results of calculations on both of this kernel that get the respondent's rating of 423 and the highest mean rank is 6.50.

The selection of kernel reconstruction should be based on clinical applications. The smooth kernel is used in the assessment of soft tissue organs to reduce noise and increase the detection of low-contrast [7]. This is in accordance with the soft tissue organ Mastoid Canalis Auditory Interna and Canalis Auditory Externa so that the assessment results obtained did not have a big effect, because the kernel H.20s smooth organ that will be seen already can be displayed. From this information it is known that the soft tissue organ of Mastoid does not require the variation of H.70s sharp and H.90s Ultrasharp kernel reconstruction to obtain optimal anatomical image information because with the use of any kernel reconstruction variations of either H.20s smooth, H.40s medium, H.70s sharp, or H.90s Ultrasharp soft tissue organs can be displayed optimally.
In figure 4, the case of fractures and hemorrhages that desperately need anatomical image information that emphasizes bone structure with the use of the H.70s sharp kernel and H.90s Ultrasharp are helpful in revealing sharper detail, whereas images with H.20s smooth and H.40 medium kernels detail of bone structure is less because it is very smooth and unsharp. For cases of fracture, good kernel variation is kernel H.70s sharp and H.90s Ultrasharp. Edge enhancing algorithm or kernel sharp emphasizes structures or improves detail but improves noise image is used in the examination to show detail, such as inner ear, bone structure [8]. As we know, the image quality is directly proportional to the anatomical information, the better image quality is also more optimal. From the information, it can be obtained that the Sharp H.70s kernel and H.90s Ultrasharp in the sinus window are the best variations to obtain anatomical mastoid CT image information. However, the Inner Ear window can be concluded to be high above 400 so that the displayed image information is also optimal. However, the higher kernel value will increase the noise, so in CT Scan mastoid examination to get good image anatomical information with noise limit is still reasonable then it is recommended to use Kernel H70s.

5. Conclusion
Kernel reconstructions have no different anatomical image information in soft tissues, Internal Auditory Canal and External Auditory Canal. There is a difference for overall anatomical information of Mastoid bones (p value<0.05). The highest values of mean rank are obtained from sharp and ultrasharp. The authors recommend to use the H.20s smooth kernel for soft tissue abnormalities and H.70s sharp kernel for fracture and bleeding cases.

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