

RESEARCH

Using Photoshop Program in Reducing Motion and Noise Artifacts On Cone Beam Ct

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ABSTRACT

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Background: Patient movement and noise artifacts are quite common during the CBCT exposure in the head and neck region. Among the underlying causes are the long duration of the device, uncontrolled movements due to the general health of the patients, and excessive mobility of the patients such as children. In this study, various filter methods and software features will be examined to remove artifacts by using Photoshop program.

Methods: Five different images with noise and motion artifact were selected. These sections were followed by specific paths with Photoshop filters. Images collected and corrected in the program were evaluated by specialist dentists. Before and after the filtering in the image evaluations, 1 to 5 criterions were evaluated by the experts. Each section was scored as 1 very inadequate, 2 inadequate, 3 normal, 4 adequate, 5 very good.

Results: As a result of the evaluation of 50 pieces of noise artifacts evaluated between 1 and 5, the average score was 4.12 points and the results were 1.62 for motion artifacts. According to the results of the Wilcoxon test, a statistically significant difference was found between the rate of postoperative correction of the sections with motion artifact and noise artifact.

Conclusion: Motion artifact and noise artifact which may occur due to many reasons are frequently encountered in CBCT examinations. In such cases, with the Photoshop program, the resulting artifacts can be reversed and can be evaluated from diagnostic point of view.

KEYWORDS

CBCT, Artifact, Noise, Photoshop

ÖZ

Konik Işınli Bilgisayarli Tomografide Hareket ve Gürültü Artefaktlarının Azaltılmasında Photoshop Programı Kullanımı

Amaç: Baş ve boyun bölgesinde konik ışınli tomografi uygulamaları esnasında hareket ve gürültü artefaktı oluşumu oldukça yaygındır. Altta yatan nedenler arasında cihazın uzun çekim süresi, hastaların genel sağlığı nedeniyle kontrolsüz hareketler ve çocuklar gibi hastaların aşırı hareketliliği vardır. Bu çalışmada, Photoshop programını kullanarak artefaktları kaldırmak için çeşitli filtre yöntemleri ve yazılım özellikleri incelenecektir.

Gereç ve Yöntemler: Gürültü ve hareket artefaktı bulunan beş farklı imaj seçildi. Bu seçim sonrasında Photoshop filtreleri ile belirli yollar izlendi. Programda işlenen ve düzeltilen görüntüler uzman diş hekimleri tarafından değerlendirildi. Görüntü değerlendirmelerinde filtrelemeden önce ve sonra, uzmanlar tarafından 1 ila 5 puan arasında olmak üzere değerlendirmeler yapıldı. Her imaj 1 çok yetersiz, 2 yetersiz, 3 normal, 4 yeterli, 5 çok iyi olarak skorlandı.

Bulgular: 1 ile 5 arasında değerlendirilen 50 adet gürültü artefaktı imajın değerlendirilmesi sonucunda, ortalama puan 4.12, hareketli artefaktı bulunan imajlar için ise 1.62'dir. Wilcoxon testinin sonuçlarına göre, hareket artefaktı ve gürültü artefaktı ile kesitlerin postoperatif düzeltme oranı arasında istatistiksel olarak anlamlı bir fark bulundu.

Sonuç: Konik ışınli bilgisayarli tomografi uygulamalarında birçok nedenden ötürü oluşabilecek hareket artefaktı ve gürültü artefaktı ile sıkça karşılaşmaktadır. Bu gibi durumlarda, Photoshop programında ortaya çıkan artefaktlar tersine çevrilebilir ve görüntüler tanısal açıdan değerlendirilebilir.

ANAHTAR KELİMELER

Konik ışınli bilgisayarli tomografi, Artefakt, Gürültü, Photoshop

Cone-beam computed tomography (CBCT) is becoming increasingly popular in dentistry because it can produce high-resolution three-dimensional images of bone and dental structures practically and quickly.^{1,2} Patient movement is quite common during the CBCT exposure in the head and neck region.³⁻⁵ Among the underlying causes are the long duration of the device⁶, uncontrolled movements due to the general health of the patients, breathing during the shooting, and excessive mobility of the patients such as children.⁷ As a result of all these reasons, patient movement causes image corruptions such as blurring, streaks, or distortion which we do not want in the final image because this makes the diagnosis difficult.⁷⁻⁹

In previous studies^{5,7,9-11}, the movement artifact has been shown to be artificially and its intensity has been changed according to the duration, distance, and type of movement. When these factors are excessive, it is stated that there will be a severe decline in image quality and difficulties in evaluation. In most of the studies, these artifacts have been tried to be prevented by using adaptive software or patient movement tracking systems and successful results have been obtained.^{8,11,12} However, in the case of these tracking systems, an additional equipment is needed. Therefore, motion artifact prevention software is provided in some devices.^{11,13}

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In addition to the motion artifact, there is also noise artifact that disturbs the image. An image is severely affected and disturbed by various factors, including the use of industrially produced components in devices, Poisson noise^{13,14}, logarithmic transformation of scaled measurements¹², and building and material-based attenuation. And in some cases, the X-ray cannot penetrate the object well, or the signal becomes noisy^{15,16}, and all the factors in addition to the projection, like these, create severe artifacts in the reconstruction area. Therefore, we need to improve the image quality by preserving the integrity of the original information and eliminating unnecessary artifacts. Many noise reduction strategies have been proposed and used to improve the signal-to-noise ratio of sections in the image area through various algorithms.¹⁷ However, the noise corresponding to the calibrated projection data after the logarithm conversion is signal-dependent.¹⁵ In order to reduce noise for projections of a CBCT image rather than a single point in the image area, this study will examine the noise reduction of two-dimensional reconstructions of pre-taken CBCT sections.

In previous studies^{12,13,18,19} noise reduction and movement artifact reduction methods have been created and corrected either through device software or with simulations or robots. In cases where these cannot be done, post- image acquisition analysis can be performed using various image editing programs. Photoshop (Adobe Systems, San Jose, CA) is a widely used image editing program for grayscale image analysis and is widely used in many medical measurements, evaluation, and commercial photo editing processes.²⁰⁻²² In this study, *reduce noise filter*, *sharpen filter* methods and software features will be examined by using Photoshop program which is more easily accessible to everyone.

MATERIALS AND METHODS

Data collecting

While collecting the data in the study, the CBCT archive screening was made in Faculty of Dentistry, Department of Oral and Maxillofacial Radiology. While selecting images, the motion artifact and noise artifact cross sections were collected, which were visibly selectable and difficult to assess correctly, regardless of age, gender, general health status, and personal information. CBCT reviews were made with the Veraviewepocs 3D R100 (J. Morita Corp., Kyoto, Japan) (60-90kV, 1-10 mA) device and its own software. Photoshop program is installed on the computer where all the research is done, and it is used for medical researches. The images are transferred to the program with the image export feature of the CBCT

software. When selecting images, five different sections were selected from five different patients' CBCT data one section each, which require precise evaluation but not possible due to artifacts, with impacted tooth-mandibular canal relation, cystic cavity, fracture line, clear information about alveolar crest desired, and with excessive root canal treatment. In terms of the study methodology, there was no need for an ethics committee approval as it does not require additional imaging from the patients, or their personal information and as previously taken images are used.

The study was conducted in accordance with the World Medical Association Declaration of Ethical Principles of Helsinki Medical Research (amended in October 2013) and the ethics committee approval was obtained from the ethics committee of our university for 2019-1931-04 / 12.

Patient movement, noise detection and correction

When assessing noise 12 in the image, the blue-green-gray pixel image was considered as noise on the screen when zooming in to cross-sectional images. (Figure 1)

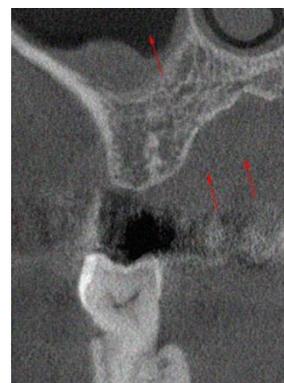


Figure 1

Distortion due to noise in the image.(cropped CBCT section)

When motion artifact was evaluated, movement-induced line artifacts, general sharpness loss and double line formation in borders were considered as motion artifacts. (motion blur). (Figure 2)

Sharpen filter was used to correct motion artifacts and a reduction noise filter was used to correct noise artifacts. And all these applications were made by an expert radiologist who knew how to use Photoshop. All of these reviews were made with Eizo® MS230W 2MP LCD (Eizo Nanao Corporation, Hakusan, Japan) monitor and i-Dixel software (i-Dixel3DX, 3D, Version 1.691; J Morita Mfg Corp.).



Figure 2
Loss of detail due to movement and double lines in borders (cropped CBCT section).

It's firstly necessary to calculate the distance moved and the angle of the movement in the Photoshop program in the removal process of motion artifacts. In order to determine the angle of movement of the sections in the transmitted sections, the boundaries of the distorted part of the image are first zoomed. And the ruler tool of the program is selected, and a parallel line is drawn to the direction of movement determined. The angle of the drawn line is read and noted in response to A in the bar of the program. (Figure 3)

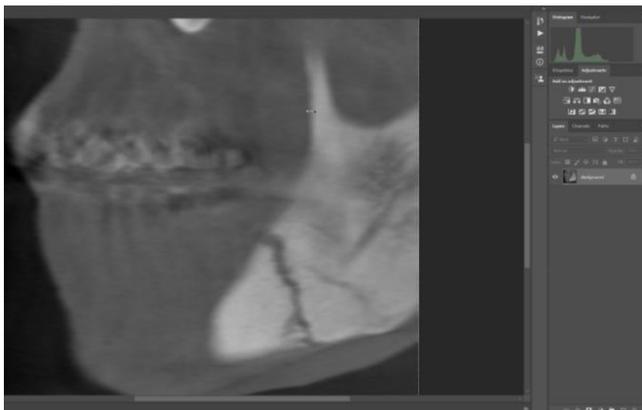


Figure 3
Line drawn in the direction of movement in the program and monitored angle(partial screenshot)

In order to calculate how far the movement is in the second step, ruler tool is selected and measured between the two outer boundaries formed in the respective region. (Figure 4)



Figure 4
Line drawn for distance measurement(partial screenshot)

This measurement can be repeated in several areas of the border to be sure. The third step is to filter with photoshop. Steps to follow in this step:

1. First of all, right click on the background image which is our main image from the layer area on the right and click on the duplicate layer tab. (Figure 5)

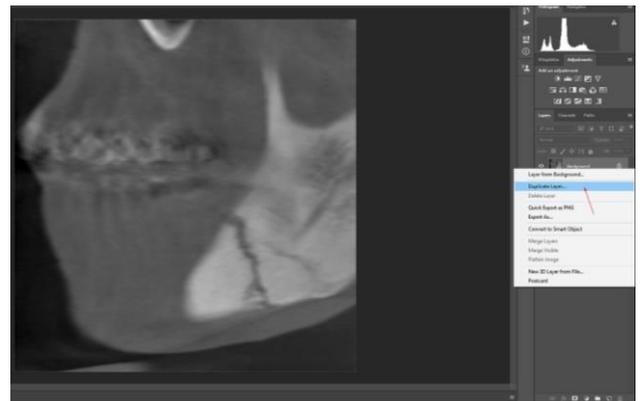


Figure 5
Action to duplicate the main image(partial screenshot)

2. Right click on the copied layer and press to convert to smart object because we may need to change the values we have noted in the filter we will use. (Figure 6)

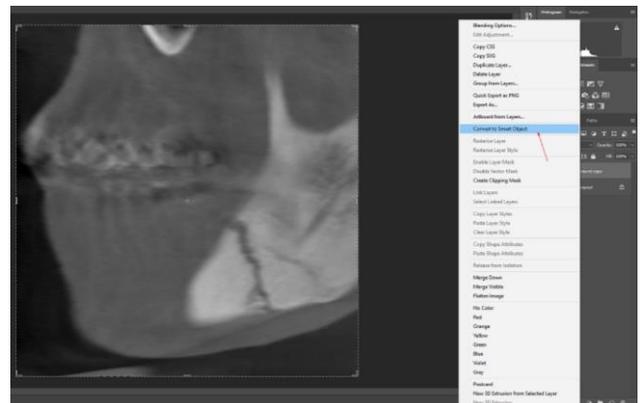


Figure 6
Convert an object to a smart object(partial screenshot)

3. Click on Filter> Sharpen> Smart Sharpen tab from the top tab of the program, and a window will appear. (Figure 7)

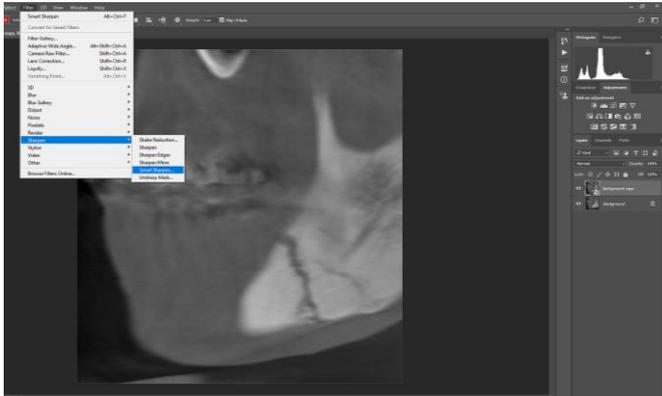


Figure 7

Path for sharpening filter(partial screenshot)

4. In the window that opens, Motion Blur is selected in the Remove section.
5. In the space just the right of the Remove tab, we enter the value we noted before and the distance value that we noted in the Radius tab at the top is entered. (Figure 8)

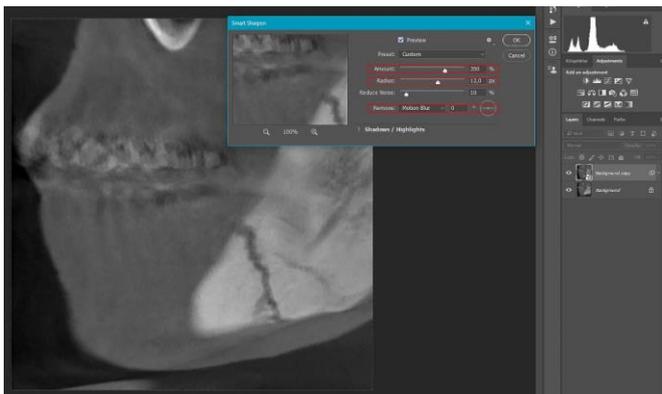


Figure 8

Entering the noted values in the pop-up window(partial screenshot)

6. On this window, reduce noise is set at an average of 10% and the amount value is set at an average of 300-350%.

Since the image to be corrected is already made in the smart object, it can be played with the values until the optimum evaluation is made.

The steps to be followed in noise reduction operations are:

1. Right-click on the background, which is our main image from the layer area on the right, and click on the duplicate layer tab. (Figure 5)
2. On the top tab of the program Filter> Noise> Reduce Noise stages are monitored, and a window opens. (Figure 9)

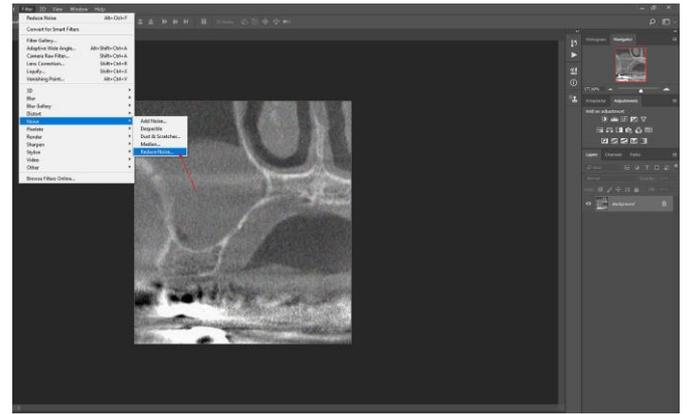


Figure 9

Path for reduce noise filter(partial screenshot)

3. *Strength* average 9, *preserve* average 0%, *reduce color noise* average 0% (for working with grayscale images), *sharpen details* are set to 10% and OK button is pressed in this window until an optimum image is obtained. (Figure 10)

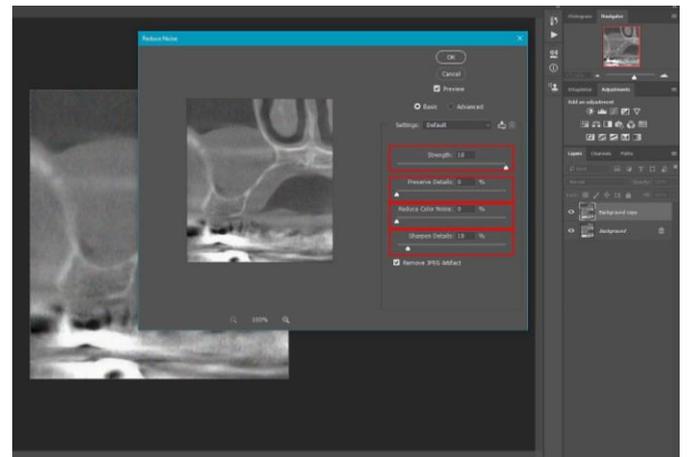


Figure 10

Entering the noted values in the pop-up window(partial screenshot)

In such post-view arrangements, noise and motion artifacts are never eliminated but can be reduced or minimalized.

Evaluation of generated images

5 motion artifacts and noise detected images and 5 generated images created with two different filters were combined and evaluated by "before-after" form by zooming. (Figure 11, 12) The evaluation was carried out by 4 experienced oral and maxillofacial radiologists, 3 experienced endodontists and 3 experienced oral and maxillofacial surgeons.

Before and after the filtering in the image evaluations, 1 to 5 criteria were evaluated by the experts. Each section was scored as 1 very inadequate, 2 inadequate, 3 normal, 4 adequate, 5 very good.

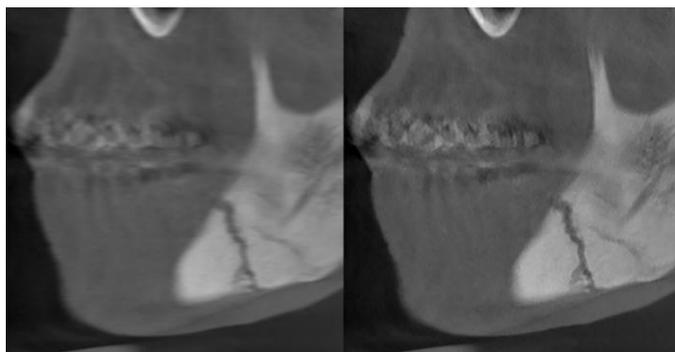


Figure 11

Evaluation of motion artifact before and after

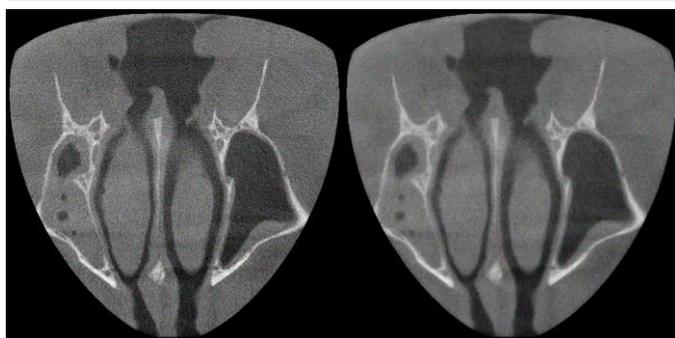


Figure 12

Evaluation of noise artifact before and after

Statistical analysis

The data were first tested for normality and the results were identified as non-parametric. ($p < 0.001$) After that, descriptive statistics and Wilcoxon Signed Ranks test were done between two sections to see the change before and after the photoshop filters. In the descriptive statistics, a total of 50 evaluations were made for the previous and subsequent sections of the noise and motion artifact sections. Spearman test was used while evaluating the interobserver agreement and the interobserver agreement was found to be 0.87 for all evaluations.

RESULTS

As a result of the evaluation of 50 pieces of noise and motion artifacts evaluated between 1 and 5, the average score was 4.12 points for noise artifacts and the results were 1.62 for motion artifacts. (Table 1)

Table 1.

Descriptive statistics and scores on artifact images and corrected images

	N	Minimum values	Maximum values	Mean	Std. Deviation
Noise artifact	50	3	5	4,12	0,435
After noise reduction	50	4	5	4,66	0,479
Motion artifact	50	1	3	1,62	0,567
After motion reduction	50	4	5	4,68	0,471

According to the results of the Wilcoxon test, a statistically significant difference was found between the rate of postoperative correction of the sections with motion artifact. ($p < 0.001$, z value: -6,265) The difference was statistically significant in the before and after evaluations of the noise artifact sections. ($p < 0.001$, z value: -5.196) Although the data collected in the noise artifacts were not rated very low in terms of evaluation, the positive results after the noise reduction filter were statistically significant. Both filters were found to be more useful for evaluation by experts.

DISCUSSION

When the artifacts in CBCT are examined, the most common artifacts are noise and motion artifacts.^{3,5,23} In order to eliminate these artifacts and to obtain better results from diagnostic examinations, many studies have been done by using motion tracking devices, motion tracking software, hardware tracking devices, and various algorithms.^{3-5,12,14,17,19} To the best of our knowledge, this is the first study that attempts to remove patient head movement and possible noise with third-party software after obtaining CBCT data and to use this data for evaluation of image quality. The study was planned retrospectively in terms of data collection, and the data and evaluations were performed on the collected data.

In the CBCT reconstruction algorithms, even though corrective software and attachments are present, devices do not detect motion, and in cases of artifacts that are not specified externally by the user, the devices present the image in an artifacted manner. When we consider the literature, we think that there are problems in terms of practicality both during financial and patient imaging, mostly with the need to use an extra hardware or software support.^{11,24} In this study, thanks to the developing technology and the Photoshop program which has a serious usage area, faulty radiographs can be re-examined and evaluated.

Another advantage of the method used in the study is that the images to be used can be processed using a Photoshop program with just one computer at any desired place and time without any preparation. Satisfactory results will be obtained for the patient and the physician during the reporting and when the necessary prints are completed by using Photoshop filters in the regions that cannot be decided during the post-op evaluation of the patient. Artifact-free images can be evaluated not only in clinical use but also in useful areas for a publication or congress presentation.

With the developing technology in the medical and

dental sciences, image processing software has become widely used. For example, the measurement of gray values in muscle and other regions 25, smile and aesthetic design 21, 22, 26, photography with dental education 27, photo manipulation detection 10 and archiving 28. In the light of all these developments and new areas of use, we have planned such a study in the name of success in clinical and academic applications.

The selected sample images included motion artifacts up to 10mm and noise artifacts that negatively affected the evaluation of the image. Recognizing that 10mm is not a very small value in terms of motion, we can say that the filters applied with Photoshop have achieved very good results and Photoshop has possible effects on fracture line and cyst-tumor boundaries and these results are statistically significant.

The limitation of the study includes the professional experience of the participants about using Photoshop, the relevant software knowledge of the person applying the filters and the number of data used in the study. Since manual measurements and angles are made during the filter application, simple errors can be seen in the evaluation and measurement of the participants. With the support of Photoshop software, human error rate can be reduced with software supports. For this situation, it may be useful to provide automatic filter support for Photoshop.

In cases where patient movement and device-related image errors are very severe, these software arrangements will still be insufficient. In further studies, it may be considered to work on the noise intensity and excess of motion of this arrangement.

This type of software support will be useful for image evaluation in cases where severe movement that can be seen due to patients (eg mental retardation, hyperactive children, parkinson's disease) cannot be prevented.

As a result, motion artifact and noise artifact which may occur due to many reasons are frequently encountered in CBCT examinations. In such cases, with the Photoshop program, the resulting artifacts can be reversed and can be evaluated from diagnostic point of view. Of course, after all these post- artifact remedies, it should be noted that not always artifacts can be removed, but only reduction or minimization will be made.

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