COMPARISON OF THE DIAGNOSTIC ACCURACY OF DIFFERENT IMAGE PROCESSING TECHNIQUES FOR DETECTION OF BONY LESIONS IN INDIRECT DIGITAL RADIOGRAPHY

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ABSTRACT

Aim: Bone lesions are common lesions out of which periapical lesions are most prevalent. Radiographs are very helpful for diagnosis of these lesions. Today various types of image processing techniques are available for all digital imaging systems. The aim of this study was to evaluate the effect of different image processing methods of diagnosis of bony lesions.

Materials & Method: In this study, 8 half mandibles of sheep were used. Artificial lesions, in 0.5, 1, 1.5, 2, 2.5, 3, 4, 5 mm diameter were produced by a round dental bur. Digital images taken from 8 half mandibles of sheep with processing methods include Sharpen, Negative and 3D Embossed filter and unprocessed images were evaluated by two radiologists. For recording results, a definitive diagnosis of the lesion was probable but correct diagnosis and failure to diagnose was considered score of 2, 1 and 0 respectively. Results were analyzed by Kruskal-Wallis test.

Results: According to the results, the chance of correct diagnosis in the images without processing and images processed with Sharpen and Negative filters was significantly higher than the images processed with the 3D Embossed filter, but the diagnostic accuracy of the unprocessed images and processed images with Sharpen and Negative filters showed no difference. Also, the more the depth of bone lesions increased, the more is the chance of correct diagnosis.

Conclusion: To detect bony lesions, digital images without processing and processed with Negative and Sharpen filters have higher diagnostic accuracy.

Key words: Radiography, Dental, Digital, Image Processing, bone lesion.

Introduction

Bone lesions are common lesions out of which periapical lesions are most prevalent. So on time diagnosis has significant role in faster recovery, prognosis and more successful treatment., while not diagnosis of lesion or diagnosis of lesion when there is no lesion can make problems. Radiography imaging are very helpful in diagnosis of these lesions.[1,2]

Diagnosis of periapical bone lesion in radiographic image is derived by some factors including location of the lesion, engagement of trabecular or cortical, and size of bone damage related to jaw dimensions in specific area.[1,3] Since there is high variation in thickness of cortex of mandibular and maxillary, a lesion with certain size can be observed in areas that have narrow cortex while in thick areas of cortex they are not observable.[2,4] Process of analysis or demineralization in bone is represented in radiolucent changes and since mineral is higher in cortical bone rather than cancellous bone, in tissue with higher mineral content such as cortical bone mineral materials are easier and faster for creating contrast. While for observing periapical radiolucency in radiographic image, 30 to 50 percent of bone mineral must be lost. Another factors such as morphologic variables, density of surrounded bone, angle of X ray and contrast of radiography have effect on radiographic interpretation.[2,5] Lesion form is also an effective factor on observing it in radiography stereotype. For instance, in fusiform if angle of incidence is in path of narrowest dimension of lesion, lesion might not be observed in graph. Although the ray is directly in way of broader dimension of lesion, it is observed as notable lesion in radiography.[2,4]

It has been many years that digital radiography has been used as a regular technique in medical affairs but direct digital imaging has been used since last decade and its usage is increasing every day.[6,7]

Today all direct digital imaging systems make different techniques of image process available. Generally, methods of image process have increased interpretability and understanding current information and provides better raw information for methods of automatic image process. Main aim of image processing is improving some features of image so that makes it more appropriate and perceivable for specific audience or application. In this process, one or some dimension of image are amended. Method of choosing these features and correction of images are determined based on certain application.[6,8]

There are many techniques for processing and improving digital image without damaging it. These methods can be classified into two methods including spatial range and frequency range methods. In spatial ranges methods, we are dealing with images pixels directly, while in frequency domain methods images are transferred into frequency domain. Spatial domain methods with pixel conversions are defined based on histogram. Histogram indicates frequency distribution of pixels value (gray scale) without considering their space.[9]

In this study, the focus is on studying image processing by spatial domain methods. Methods that are used regularly for processing digital radiography images include as follow:

- Shadow
- Sharpen
- Sigmoidal
- Exponential
- Negative and
- 3D Embossed.

But the point is there is no specific scale for showing certain quality of images for human audience or for certain diagnostic application. In other word, processed images may meet diagnostic needs by one method while in other methods they show insufficient diagnostic quality.[9]

Since it is very important to detect bone lesion as soon as possible and according to effect of diagnosis of these lesions on radiographies without processing anatomic and geometric factors, we aimed at studying effect of different methods of processing on digital images on diagnosis of bone lesion and then be able to classify filters in terms of maximum benefit for diagnosis of these lesions.

Materials & Method

In order to perform this experimental study, 8 half mandible of sheep was used. [Figure 1]

Since all lesions which include 8 lesions with different dimensions are created in sheep jaw, there is no sample volume. In order to cleanse soft tissues, bone was debridement by periosteal elevator and they were put in formaldehyde solution in order to control infection.

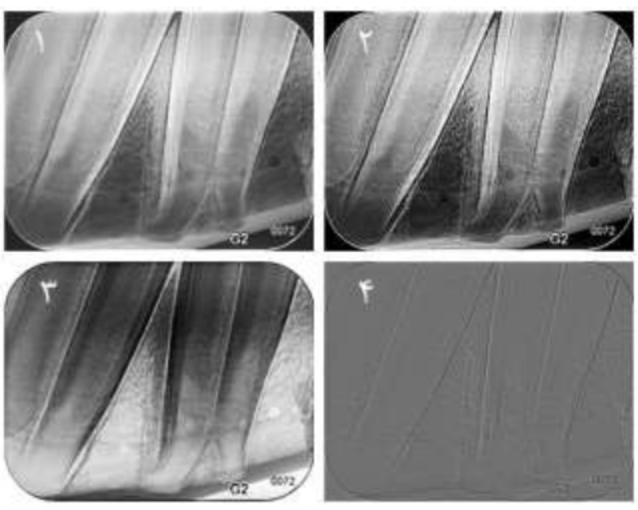

Figure 1: unprocessed digital images (number 1) and processed one with Sharpen filters (number 2), negative (number 3) and 3D Embossed (number 4) from half mandible of sheep for diagnosing bony lesion.

Lesions were created by high round hand piece and surgical diamond bur with 021-801 (Buchler Ltd, Lake Bluff. IL, USA) numbers by 0.5,1, 1.5, 2, 2.5, 4 and 5mm depth. Depth of lesion for cortical bone was 0.5 to 2.5 mm, for connecting place of cortical and Cancellous bone (according to thickness of cortical bone in cutting place is diagnosable and measurable and feeling of bone density change) and depth of 3.5 to 5mm for Cancellous bone. The only person that was aware of the process was the person that created the holes and depths. After creating lesions, a digital image was provided from half mandibular and images were studied by two radiologists (so observer must have diagnosed 64 created holes in half mandible). In order to make possible proving radiography films from fixed distance and angle between ray resource and samples and PSP sensors, half mandible was placed in plastic space so that it could be fixed when it was under ray generator. In this study de Gotzen (Xgenus, Italian design) was used by 70 kVp exposure, 8 second milliampere, 0.32 second. Then images were processed by Scanora software in three forms of Sharpen ‹Negative and 3D Embossed. [Figure 1]

Reading images and recording results were as follow: people in charge recorded lesion numbers on certain form. For correct lesion diagnosis the score was 2, for probable diagnosis and correct it was 1, for false diagnosis or no diagnosis the score was zero. Diagnostic quality was calculated based on lesion diagnosis by observers. Lesions that were not detectable or they were detected by mistake(weak=0), lesion that was correctly diagnosed considered as (average=1) and lesion which were diagnosable accurately were considered as (perfect=2).

Collected information were analyzed by SPSS software 22th version by Kruskal–Wallis and Kappa agreement coefficient. Significance level was $p<0.05$. Sensitivity, specificity and accuracy of applied methods were calculated.

Results

The scores recorded by observers for images without processing and images processed by Sharpen ‹Negative and 3D Embossed were analyzed in order to determine the best filter for diagnosis of bone lesion. They also studied if there is significant relationship between processed images by applied filters and unprocessed images in terms of accuracy of lesion diagnosis. In addition, they attempted to find out which bone lesion in images processed by mentioned filters and images that unprocessed gain scores higher than observers. Thus in one step diagnostic accuracy of images processed and not processed by three mentioned filters were studied without considering depth of bone lesion and score gained by observers and then diagnostic accuracy of bone lesion were studied considering different depth and scores that observers determined.

Comparing images that were not processed and images processed by Sharpen filter, chance of accurate diagnosis in first section is 0.844 higher than second section. So this difference was not significantly different (p=0.660). In images that were not processed and images processed by negative filter, chance of accurate diagnosis in first section was 0.886 equals to third section. So this difference was not significantly different (p=0.489). In images that were not processed and images processed by 3D Embossed filter, chance of accurate diagnosis in first section was 1.98 equals to fourth section. So this difference was not significantly different (p=0.038). Comparing diagnosis chance of images that were processed by Sharpen filter was 1.050 more accurate than images processed by Negative filter. So this difference was not significantly different (p=0.834). Diagnosis chance of images that were processed by Sharpen filter was 2.34 more accurate than images processed by 3D Embossed filter. So this difference was not significantly different (p=0.001). Diagnosis chance of images that were processed by Negative filter was 2.23 more accurate than images processed by 3D Embossed filter. So this difference was not significantly different (p=0.001).

Generally, chance of more accurate diagnosis in unprocessed images and images processed by Sharpen and Negative filter is significantly higher than images processed by 3D Embossed. However, diagnostic accuracy in images not processed and images that were processed by Sharpen and Negative filters was not different. [Diagram 1]

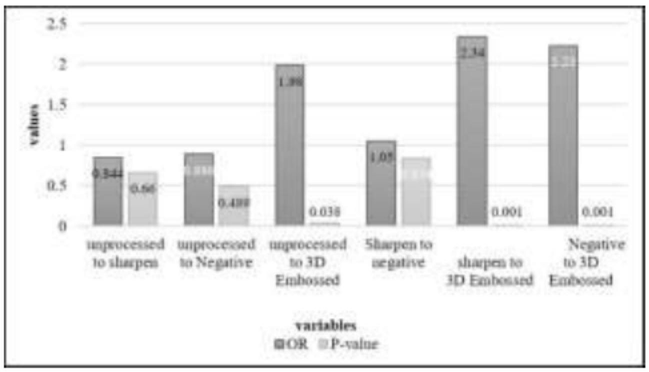

Diagram 1: Comparing diagnostic accuracy of unprocessed images and images processed by Sharpen, Negative and 3D Embossed without taking depth of bone lesion into account by Kruskal–Wallis (p<0.05)

In studying diagnostic accuracy of bone lesion with 8 different depths, in order to make providing statistical results simple, these lesions were divided into three sections; first section included lesions with 0.5, 1 and 1.5 mm depth, second section included lesions with 2, 2.5 and 3mm depth and third section included lesions with 4 and 5 mm depth.

Comparing diagnostic accuracy of deep bone lesion by 4 and 5 mm depths (third section) with lower depth bone lesion in first section, chance of more accurate diagnosis in third section was 20.26 times higher than first section and this difference is significant statistically (p=0.001). In studying diagnostic accuracy of bone lesion in third section (4 and 5 depth) rather than second section lesion (2, 2.5 and 3 depths) chance of more accurate diagnosis is 6.85 time higher in second section. And this this difference is significant statistically (p=0.001). Comparing diagnostic accuracy of deep bone lesion in second with lower depth lesion in first section, chance of more accurate diagnosis was equals 2.955 and this difference is significant statistically (p=0.001). These results stated that the deeper is bone lesion the higher is possibility of accurate diagnosis. [Diagram 2]

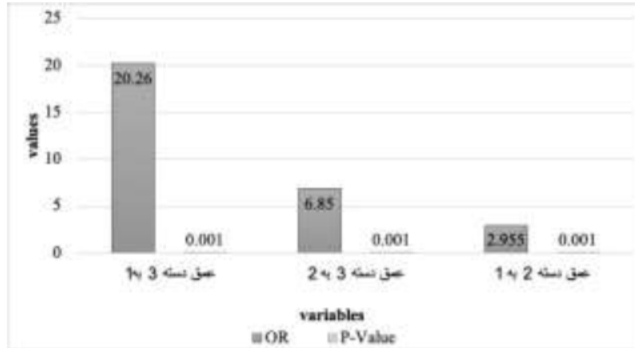

Diagram 2: Comparing diagnostic accuracy of bone lesion with different 8 depths by Kruskal–Wallis test (P<0.05). (section 1: 0.5, 1 and 1.5 mm- section 2: 2, 2.5 and 3 mm, section 3: 4 and 5 mm)

In addition, data were assessed and analyzed so agreement degree of both observers was calculated by 0.723 which is good (p=0.001).

Discussion

In digital technology methods of image processing are used for accessing to better diagnosis. These methods are basic for changing one or more features of the image based on this diagnosis aim filter type is chosen in order to improve diagnostic quality of images. However, there has been no study focusing solely on different filters and came up with general conclusion. It might be due to lack of certain standard for choosing filters in order to improve quality of the image and choosing them by chance are the clearest barriers for this. In few studies on filters there has been few studies focusing of general application of filters because mostly enhancement methods are used.[6]

Due to high prevalence of peri apical lesion and the importance of diagnosis, this study investigated diagnostic accuracy of bone lesion by different methods of processing digital image and also studied diagnostic accuracy of bone lesion by different depths. Eight half mandibles of sheep was provided and eight holes with 0.5,1,1.5,2,2.5,3,4 and 5 were created by high round hand piece and diamond bur. These depths of holes on half mandible of sheep were selected by chance. One image was provided from each half mandible and they were processed by three filters including Sharpen, negative and 3D Embossed and then these images and unprocessed images were provided for two observers in order to score these images. Results indicated that unprocessed images and images processed by Sharpen, negative and 3D Embossed had similar diagnostic accuracy. However, diagnostic accuracy of all three filters was significantly higher than 3D Embossed filter. In addition, investigating bone lesion with different depths showed that the more lesion is deep the more accurate is diagnostic chance.

Method of this study was similar to Tabrizi Zadeh *et al* (2013). But Tabrizi Zadeh *et al* compared accuracy of ordinary and digital radiography methods. While in this study accuracy of difference methods of digital image processing and unprocessed digital images were investigated which is advantage of this study. In Tabrizi Zadeh *et al* study, lesion created by 3mm depth or higher in both digital and ordinary method were diagnosed correctly by observers. However, lesion with depth lower than 3 m in digital radiography were diagnosed better than ordinary radiography.[10] Based on results, in this study by increase of lesion depth, chance of more accurate diagnosis is higher while in this study digital unprocessed images and images processed by different filters were investigated.

In another study performed by Tabrizi Zadeh *et al* (2011) they investigated accuracy of ordinary and digital radiography methods in diagnosis of bone lesion which was produced by hydrochloric acid. In this study, after 36 hours that chemical lesion was created, probability of lesion diagnosis in digital images is significantly higher than images provided by ordinary radiography. In this study in contrast to previous study, depth of lesion was the same however results were similar to previous study, so it proves superiority of digital radiography than ordinary radiography.[11]

One important issue in investigating results of researches on periapical lesion diagnosis method is that they mostly have been performed experimentally while nature of created artificial lesions is different with real periapical lesion. So that a real peri apical lesion is derived by complicated setting of immunologic and inflammatory processes that can be distributed in various sides and it does not produce a lesion with clear edge that can be diagnosed simpler necessarily.[5] However, in artificial models that lesions are created by hand piece with various bures, lesions are created with obvious edges that their appearance is totally different with real periapical lesion. In addition, in experimental research, clinical condition is not able to be retrofitted in terms of soft tissue and angle of ray. On the other hand, anatomy and density of the bone in animals is different with human being.[12,13] In recent study, in contrast to mechanical lesion, created lesions by chemical way do not produce obvious edge so diagnosis is made in more similar clinical condition which is advantage of this study.

In Dabaghi *et al* study (2014), diagnosis quality of anatomic structures and general quality of the image were compared by different methods of processing medical images in direct digital panoramic radiography. Although in another study on panoramic images they compared different methods of direct digital image processing. According to Dabaghi *et al*[6] results which studied all landmarks in unprocessed images and images processed by Sharpen, Negative, Shadow, Exponential, Sigmoidal, 3D Embossed and comparing all method it was illustrated that Sharpen obtained highest score. Then other filters and unprocessed images obtained different scores in diagnosis of landmarks. Although in studying ligament space of periodontal of mandibular first right molar, highest score was obtained by unprocessed images and images processed by Sigmodial filter. While in considering DEJ of maxillary first right molar highest score was related to Negative filter and unprocessed images. In our study, diagnostic accuracy of unprocessed images and images processed by Negative and Sharpen filters was significantly higher than images processed by 3D Embossed. However, there was no significant difference in unprocessed images and images processed by Sharpen filter and Negative filter in diagnosis of bone lesion which is not along with our colleagues' results.

In a study made by Wenzel and Hintze (1993) on using filters in inter oral radiography was concluded that Sharpen filter acts better in diagnosing bone lesion, caries and also anatomic landmarks.[13] Although this is similar to our conclusion but in our study there was no significant difference between images processed by Sharpen filter, images processed by Negative filter and image without process in diagnosis of bone lesion.

Conclusion

To detect bony lesions, digital images without processing and processed with Negative and Sharpen filters have higher diagnostic accuracy. So, for more accurate diagnosis of bone lesion using digital images without process and images processed with Sharpen and Negative filters are recommended.

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