International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 5, May-2014, pp: (138-144), Impact Factor: 1.252, Available online at: www.erpublications.com

Quantitative Analysis by Pixel Intensity and Fractal Dimensions for Imaging Diagnosis of Periapical Lesions

Shahrazad Sami Saeed[1], Usama Morad Ibraheem[2], Manar Mudhafar Alnema[3]
[123]Oral & Maxillofacial Surgery, College of Dentistry, University of Mosul, Iraq

Abstract

Aims of study: To perform quantitative analysis of periapical lesions by pixel intensity, fractal dimensions in diagnosis of periapical lesions.

Subjects, Material and Methods: Twentysix patients aged between 8-40 years classified as age groups: Group 1 from 8-18 years, Group 2 from 19-29 years, Group 3 from 30- 40 years and with periapical lesion in maxillary and mandibular anterior teeth and premolars diagnosed by their clinical sign and symptoms and radiographic findings who attended to the maxillofacial unit in al Al Jamhori Teaching Hospital and Specialist Center of Dentistry/Right bank in Mosul city were include in this study. The periapical radiograph for all twenty six patients had taken by bisecting angle technique. All The periapical radiograph, then digitize to convert them to the digital form for detection pixel intensity, the developed imagej software version 1.34s software was used for image processing then found the pixel intensity for all lesions and also histogram.Periapical lesion shows fractal behavior which isquantitative evaluation of periapical area and fractal dimensions also measured.

Result: Significant correlation found between pixel intensity and fractal dimension and histopathological result.

Conclusion:Fractal dimension and pixel intensity calculation could be recommended as a quantitative and objective method for the differential diagnosis of clinical suspicious periapical lesions.

Key words: periapical lesions, pixel intensity, fractal dimensions.

INTRODUCTION

Periapical inflammatory lesions occur as a local immune response of periradicular tissue to the chronic stimulation caused by microorganisms that invade and destroy the dental pulp[1;2;3] The fundamental principle of periapical inflammatory lesion involve the progression of a bacterial infection from the dental pulp to the apical foramen which results in a localized inflammatory response concurrent with bone resorption identified as a radiolucent in radiographs.Histopathological categories of periapical lesion referred to as apical periodontitis[4,5,6,7,8] Apical periodontitis means a group of inflammatory disorders of the periapical tissues caused predominately by a mixed microbial infection in the endodontic system of the affected tooth[9;10;11] Digital imaging, with pixel intensity, holds the possibility of qualitative and quantitative analyses of bone density and architecture. Pixel intensity (PI) analysis consider as a simple method that provide objective measures of radiographic density of alveolar bone[12] Its means measurement of blackness or whiteness in a 8-bit digital image on a scale from zero (totally black) to 255 (totally white)[13] The number and size of the pixels, together with the number of shades of grey available in radiograph, decided the amount of information in an image[14] The word ‘‘fractal’’ comes from the Latin word fractus that means fracture or broken[15;16] Its defined as a mathematical methods for describing and analyzing complex shapes and structural patterns, expressed numerically as fractal dimension (FD)[12]

So that, the fractal dimension utilized to estimate complex geometric structures quantitatively. Generally, the higher the dimension, the more complex the shape[17;18;19] The complexity of the structure is represented by a single number that is calculated with a computer algorithm[20] Several techniques for fractal dimensions calculation were proposed, with box counting method being the most commonly employed in dental radiology[21;22] Box-counting algorithm is predominately employed to quantify the trabecular pattern by counting the trabecular bone and bone marrow interface. The method also assesses the boundary of trabecular bone and marrow, a higher box counting value indicates a more complex structure[21;23] Fractal dimensions is stand for as the absolute value of the slope of the least square regression line[24] Essentially, the fractal dimensions methods are reported to be unaffected by difference in exposure, alignment,

and choice of region of interest[25] In dental radiology, the fractal dimension calculation was utilized to estimate and quantify the trabecular bone structure for the detection of bone changes associated with periapical periodontitis, periodontal disease, bone surgery and systemic diseases[23;25;26;27;28] Fractal dimensions have also been utilized for estimation of dental implant sites and detection of osteoporosis[18;29]

MATERIAL AND METHODS

Twenty six patients aged between 8-40 years classified as age groups: Group 1 from 8-18 years, Group 2 from 19-29 years, Group 3 from 30- 40 years and with periapical lesion in maxillary and mandibular anterior teeth and premolars diagnosed by their clinical sign and symptoms and radiographic findings who attended to the maxillofacial unit in al Al Jamhori Teaching Hospital and Specialist Center of Dentistry/Rightin Mosul city were include in this study. Informed consent was taken from all the patients before their inclusion in the study. A special patients record sheet was formulae to record the history, clinical examination, radiographic findings,ultrasound examination and histopathological examination.

Conventional Periapical Film Radiographic Examination

The periapical radiograph for all twenty patients had taken by bisecting angle technique. Dental x-ray unit (68kVp,8Ma, 2 mm filtration) and Kodak E –speed used to take the periapical radiograph. This technique involve that the appropriate sized film packet(size 2), is positioned and orientated in the mouth with about 2 mm extending beyond the incisal or occlusal edges, to ensure that all of the tooth will appear on the film. The patient is then asked to gently support the film packet using either an index finger or thumb keeping the film as close to the teeth as possible. The central x- ray beam is directed perpendicular to the imaginary bisector that bisects the angle formed by long axis of the tooth and the film. The imaginary bisectors creates two equal angles and provides a common side of the two imaginary equal triangles, the two imaginary triangles are right angles and are congruent. The conventional radiographs were then processed automatically in fresh chemicals, the radiographs were viewed and evaluated on a viewing box under normal operating illumination and the surgeon specialist in maxillofacial unit were asked to make a detailed description of periapical lesion. All The periapical radiograph then digitize to convert them to the digital form for detection pixel intensity, the developed imagej software version 1.34s software (National Institutes of Health, Bethesda, MD; http://rsb. info.nih.gov/nih-image). NIH Image is a public domain program that can be downloaded from the World Wide Web (http://rsb.info.nih.gov/ij/Java 1.3.1_13),was used for image processing then found the pixel intensity for all lesions and also histogram. The pixel intensity was analyzed after analogue radiographs were scanned into a computer. The histogram (Histogram plot the pixel intensities in x-axis and the corresponding number of pixels in the y-axis) of the image is computed and stored in a variable, and then the index value of the histogram that has the maximum number of pixels is noted.

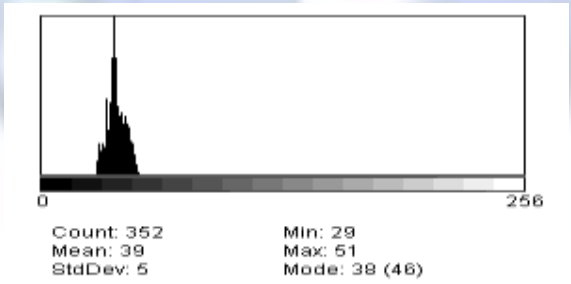

Figure (1): Index value of the histogram that has the maximum number of pixel

Periapical lesion shows fractal behavior which is quantitative evaluation of periapical area. All procedures for calculation of the fractal dimension were performed by using Image J version 1.34s software. Region of interested(ROI)were selected as 22 _ 16 pixel-sized squares that located at the apex of tooth. Lamina dura, periodontal ligament and related regions, and root apices were not included within ROI. The saved images were processed using the method developed by Demirbas et al. (2008)[46] methodology. The region of interst(ROI) were cropped and were transferred to Image J version 1.34s by using the program menu. To remove the fine-scale and medium-scale variations in image brightness caused by the difference in the thickness of the object and the radiation exposure, the cropped ROI was duplicated and the duplicated image was blurred with a Gaussian filter (kernel size _ 35). The blurred image was then subtracted from the original image and then the resultant image was converted to binary by threshold at the gray value of 128 so that the segmented objects approximated the bony trabecular pattern. With this process, the regions that represent trabecular bone were set to black and marrow spaces were set to white. Finally, the image was skeletonized and was used for fractal analysis. On skeletal binary image, the skeletal structure indicated the bone pattern, whereas non skeletal structure represented the bone marrow. All digital manipulations and measurements were made within the

ROIs rather than of the entire original intraoral radiograph. The fractal dimension of the skeletonized image was calculated with Image J version 1.34s by using the box-counting function from "analyze" menu, as follows: the image was covered by a square grid of the equally sized tiles and the number of tiles containing at least black pixel (which refers to the trabecular bone) was counted. The width of the square boxes were 2, 3, 4, 6, 8, 12, 16, 32, and 64 pixels. The resulting number of the counted tiles were plotted against the total number of the tiles in double logarithmic scale and FD was calculated from the slope of the line fitted on the data points.

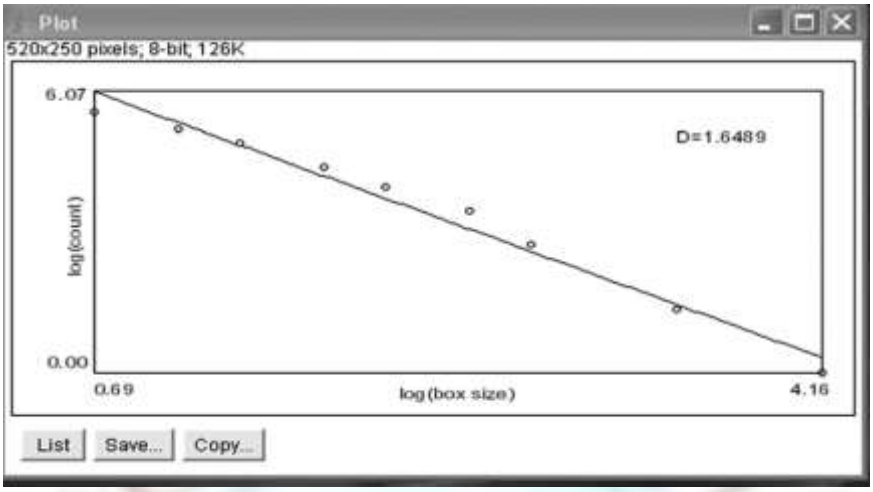

Figure (2): Slope of the line fitted to the data points along with the FD Value

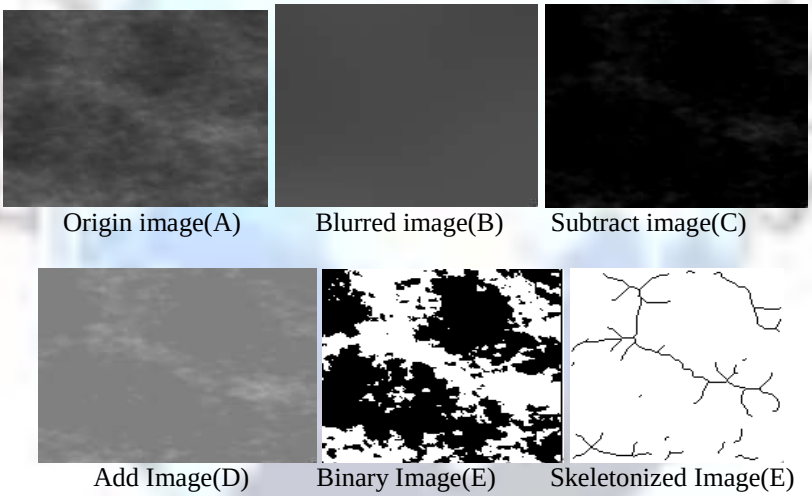

Figure (3). Steps of fractal dimensions measurement; A: a region of interest from a digitized radiograph of the periapical area of maxillary central incisor; B: the result of blurring this region; C: the result of subtracting B from A; D: adding 128; E: binary version of image C; F: keletonized image.

RESULT

Table (1): Descriptive Statistics of pixel intensity

	N	Mean	Std. Deviation	Std. Error Std. Error	Minimum	Maximum
Cyst	6	1.265800	0.1122517	0.0458266	1.1854	1.4887
Abscess	5	1. 227880	0.0492093	0.0220071	1.1440	1.2672
Granuloma	11	1.080864	0.0756884	0.0228209	0.9428	1.1735
Phoenix abscess	4	1.126457	0.1469727	0/0734864	1.0137	1.13311
Total	26	1.158831	0.1197209	0.0234792	0.9428	1.4887

Table (2): ANOVA statistics for pixel intensity

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Cyst	6	54.83	3.371	1.376	49	85
Abscess	5	44.40	5.595	2.502	38	51
Granuloma	11	103.18	21.165	6.382	84	148
Phoenix abscess	4	79.00	12.356	6.178	61	89
Total	26	77.00	28.940	5.676	38	148

Table(3): Duncan's Multiple Range Test of pixel intensity

	Sum of Squares	Df	Mean Square	F	P-value
Between groups	15818.330	3	5272.777	22.658	0.000
Within groups	5119.670	22	232.712		
Total ف	20938.000	25			

Table(4). Descriptive Statistics of fractal dimensions

Group	N	Duncan's grouping		
		A	B	C
Abscess	5	44.40		
Cyst	6	54.83		
Phoenix abscess	4		79.00	
Granuloma	11			103.18

Table (5) ANOVA statistics of fractal dimensions

	Sum of squares	df	Mean	F	P- value
Between groups	0.164	3	0.055	6.158	0.003
Within groups	0.195	22	0.009		
Total	0.358	25			

Table(6) Duncan's Multiple Range Test of fractal dimensions

Group	N	Duncan's Grouping		
		A	B	C
Granuloma	11	1.080864		
Phoenix abscess	4	1.126475	1.126457	
Abscess	5		1.227880	1.227880
Cyst	6			1.265800

p -value is 0.001

DISCUSSION

When the user adjusts the whole image to make it more suitable for diagnostic purposes, the term "image processing" usually is applied[30] Image processing techniques are an acceptable technique that can be used to assist dentists in improving the diagnosis[31;32] Image processing enables extraction of signals of diagnostic interest from a radiograph. However, it cannot produce information that is missing[33] The interest in digital image processing methods has arisen from the recent possibilityof improving the quality of visual information for human interpretation[34] Particularly in oral pathology, this improvement in image quality is essential for a better diagnosis, especially if the original source of the digital image is a conventional radiograph[35] Our study proved that the granuloma had higher pixel intensity than abscess and cyst which may be due to the content of cyst which is fluid and abscess which is pus and exudates and this give lower gray scale level than granulation tissue of granuloma, while phoenix abscess has pixel intensity between granuloma and abscess and this may be due to phoenix abscess is granuloma with abscess formation and this give lower gray value and this finding disagree with the result of Shrout et al.,1993 , who found that granulomas had a narrower range and lower grayscale value than did cysts[36].

In the present study we further assert that variation in the gray scale value of a periapical lesion is associated with histological changes, with a direct correlation between the value and the type of material that fills the lesion, and this result consistent with Camps et al .,2004[37] Teixeira et al.,2010revealed that the pixel intensity values in the areas of periapical disease induced in rats indicated greater bone resorption than the means of these values on the control side for the three experimental periods ($p<0.05$). Even small periapical bone resorption was already sufficient for determining changes in the pixel values of that area in the direct digital method, when compared to their respective controls[47].The pattern of bone trabecule characterized by a number of measures including area of the bony plates, circumference of the trabeculae, number of bony and marrow regions, thickness of the trabeculae, trabecular spacing, and osseous fractal dimension[38] It has been demonstrated that cancellous bone is made of interconnected trabecular structures with an underlying geometric pattern, thus making it a tool for defining a mathematical fractal pattern[39]

Periapical lesion shows fractal behavior which is quantitative evaluation of periapical area. This method is difficult to use for quantifying an entire radiolucent lesion because it may only be employed on a small fragment of that radiolucent area. Nearby anatomy such as sinus and proximity to adjacent structures such as root apices can participate to noise and degrade benefit information. With these limitations in mind, fractal analysis has been capable to detect early changes in periapical trabecular pattern in a defined small region of interest on periapical radiographs and this agree with the results of Chen et al., 2005; Yasar and Akgunlu, 2005[21;40]. Our study explained that fractal dimensions increase in chronic periapical abscess and cyst as the bone density have been decreased and demineralization increase, this result is in harmonies with the result of Ruttimann et al.,1992, who investigated the structural changes on ten dry mandible fragments before and after decalcification with acid and found that fractal dimension increased as demineralization increase[18].

The explanation of this result in that the loss of fine trabecular structure as a result of demineralization may produced abrupt density changes in radiographical images and thus cause changes in the fractal dimension. In other words elevation in fractal dimension may occur as a reflection of increase in the roughness of the image corresponding to the architectural disorganization of trabecular network via demineralization and this agree with the result with Yasar and Akgunlu,2005; Sogur et al.,2013; Chen and Chen,1998[40;41;42] But this result is disagree with the results of Southard et al.,1996,whom established that decreasing value of fractal dimension occur with increased decalcifications[43].The

diversity of the results has been explained by anatomical variations, discrepancies in the techniques employed to acquired two-dimensional bone images, procedures for measuring fractal dimension and/or differences in region of interested to be measured and this agree with Pornprasertsuk et al.,2001[44] Our result established that fractal dimension reduced in granuloma and phoenix abscess as the demineralization of bony trabecule is less than that in cyst or abscess and may due to granulation tissue formation this result is in harmonies of the result of Sogur et al.,2013[41] Our study demonstrated significant correlation between pixel intensity and histopathological result and this results agree with result of Raghav et al .,2010 also our result shows significant correlation between fractal dimension and the result of histopathological examination and this result again is similar to the results of Raghav et al .,2010[45]

CONCLUSIONS

- Pixel intensity and histogram can be used for differential diagnosis of periapical lesion
- Fractal dimension calculation could be recommended as a quantitative and objective method for the detection of clinically suspicious periapical lesions

REFERENCES

[1]. Stashenko P.Role of immune cytokines in the pathogenesis of periapical lesions. Endod Dent Traumatol.1990;6:89—96.
[2]. White SC and Pharoah MJ . Oral Radiology: Principles and Interpretation. Sixth Edition, Mosby St Louis; Canada.2009: Pp221-222
[3]. Sasaki H, Hou L, Belani A, Wang C-Y, Uchiyama T, Muller R and Stashenko Ph. IL-10, But Not IL-4, Suppresses Infection-Stimulated Bone Resorption In Vivo. Journal of Immunology. 2000; 165: 3626–3630
[4]. Kabak SL, Kabak YS, Anischenko SL. Light microscopic study of periapical lesions associated with asymptomatic apical periodontitis. Ann Anat. 2005;187:185–94.
[5]. Ahmed GA, ElBaz A A, Hashem AAR, and Shalaan A K. Expression Levels of Matrix Metalloproteinase-9 and Gram-negative Bacteria in Symptomatic and Asymptomatic Periapical Lesions. J Endod. 2013 ;39:444–448
[6]. Boyle WJ, Simonet WS, Lacey DL. Osteoclast differentiation and activation. Nature. 2003;423:337-42.
[7]. Nadalin MR, Fregnani ER, Silva-Sousa YT, et al. Presence of myofibroblasts and matrix metalloproteinase 2 in radicular cysts, dentigerous cysts, and keratocystic odontogenic tumors: a comparative immunohistochemical study. J Endod. 2012; 38:1363–7.
[8]. Stashenko P, Teles R, D'Souza R. Periapical inflammatory responses and their modulation. Crit Rev Oral Biol Med.1998;9: 498–521.
[9]. Abbott P V. Classification, diagnosis and clinical manifestations of apical periodontitis. Endodontic Topics. 2004 ; 8, 36–54
[10]. Xia M and Qi Q.Bacterial analysis of combined periodontal-endodontic lesions by polymerase chain reactiondenaturing gradient gel electrophoresis. Journal of Oral Science.2013;55(4) 287-291
[11]. Estrela C,Leles C R, Hollanda A C B, Moura M S, Pécora J D. Prevalence and Risk Factors of Apical Periodontitis in Endodontically Treated Teeth in a Selected Population of Brazilian Adults. Braz Dent J.2008; 19(1): 34-39
[12]. Tosoni GM, Lurie AG, Cowan AE, Burleson JA, and Farmington CT. Pixel intensity and fractal analyses: detecting osteoporosis inperimenopausal and postmenopausal women by using digital panoramic images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;102:235-41
[13]. Guiherme M, Alan G, Ann E and Joseph A. Pixel intensity and fractal analyses in detection osteoporosis in premenopausal and postmenopausal women by using digital panoramic finding. J Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006; 102:235-41
[14]. Whaits R and Cawson RA. Alternative specialized imaging modalities. Essential of dental radiography and radiology. Third Edition.CHURCHILL LIVINGSTONE. LONDON.Ch 17.2003:205
[15]. Sanchez I and Uzcategui G. Fractals in dentistry. Journal of dentistry. 2011; 39: 7 3– 29 2
[16]. Sansare K, Singh D and Karjodkar F.Changes in the fractal dimension on pre- and post-implant panoramic radiographs. Oral Radiol. 2012 ; 28:15–23
[17]. Caligiuri P, Giger ML, Favus M. Multifractal radiographic analysis of osteoporosis. Med Phys. ;1994 21: 503–508
[18]. Ruttimann UE, Webber RL, Hazelrig JB. Fractal dimension from radiographs of peridental alveolar bone. Oral Surg Oral Med Oral Pathol.1992;74:98–110.
[19]. Geraets G M and van der Stelt P F."Fractal properties of bone," Dentomaxillofac Radiol.2000; 29: 144-153.
[20]. Jolley L, Majumdar S, Kapila S. Technical factors in fractal analysis of periapical radiographs. Dento-Maxillo-Facial Radiol.2006;35:393–397
[21]. Chen SK, Oviir T, Lin CH, Leu LJ, Cho BH, Hollender L. Digital imaging analysis with mathematical morphology and fractal dimension for evaluation of periapical lesions following endodontic treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005; 100 : 467-72.
[22]. Majumdar S, Weinstein RS, Prasad RR. Application of fractal geometry techniques to the study of trabecular bone. Med Phys. 1993; 20:1611–1619
[23]. Ergun S, Saracoglu A, Guneri P, Ozpinar B. Application of fractal analysis in hyperparathyroidism. Dentomaxillofaci Radiol. 2009;38:281–288
[24]. Uchiyama T, Tanizawa T, Muramatsu H, Endo N, Takahashi HE,Hara T. Three-dimensional microstructural analysis of human trabecular bone in relation to its mechanical properties. Bone Vol.1999;25:487-91.
[25]. Heo MS, Park KS, Lee SS, Choi SC, Koak JY, Heo SJ, et al. Fractal analysis of mandibular bony healing after orthognatic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod.2002;94:763-7.

[26]. Yu Y-Y, Chen H, Lin C-H, Chen Ch-M, Oviir T, Chen S-K and Hollender L. Fractal dimension analysis of periapical reactive bone in response to root canal treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod.2009;107:283–288
[27]. Updike SX, Nowzari H. Fractal analysis of dental radiographs to detect periodontitis-induced trabecular changes. J Periodontal Res.2008; 43:658–664
[28]. Bollen AM, Taguchi A, Hujoel PP, Hollender LG. Fractal dimension on dental radiographs. Dentomaxillofac Radiol. 2001; 30:270–275
[29]. Wilding RJ, Slabbert JC, Kathree H, Owen CP, Crombie K, Delport P.The use of fractal analysis to reveal remodelling in human alveolar bone following the placement of dental implants. Arch Oral Biol. 1995; 40: 61–72.
[30]. Van der Stelt PV. Better imaging The advantages of digital radiography. JADA. 2008;139(6):7-13
[31]. Alves WEGW, Ono E, Tanaka JLO, Filho EM, Moraes LC, Moraes. MEL & Castilho JCM. Influence of image filters on the reproducibility of measurements of aveolar bone loss, Journal of Applied Oral Science.2006; 4(6): 415 – 420
[32]. Sund T & Moystad A.Sliding window adaptive histogram equalization in intraoral radiographs: effect on image quality. Dentomaxillofacial Radiology. 2006;35:133-138
[33]. Nair M K, Odont. L, Abomr D and Nair U P. Digital and Advanced Imaging in Endodontics: A Review. J Endod. 2007; 33:1– 6
[34]. Raitz R, Junior JNR A , Fenyo-Pereira M, L Correa L and de Lima LP. Assessment of using digital manipulation tools for diagnosing mandibular radiolucent lesions. Dentomaxillofacial Radiology .2012 ;41:203–210
[35]. Wenzel A and Hintze H. Perception of image quality in direct digital radiography after application of various image treatment filters for detectability of dental disease. Dentomaxillofac Radiol. 1993;22: 131–134.
[36]. Shrout MK, Hall JM and Hildebolt CE.Differentiation of periapical granulomas and radicular cysts by digital radiometric analysis. Oral Surg Oral Med Oral Pathol.1993;76:356–61.
[37]. Camps J, Pommel L, Bukiet F. Evaluation of periapical lesion healing by correction of gray values. J Endod. 2004; 30(11): 762-766.
[38]. Parfitt AM(1987). Trabecular bone architecture in the pathogenesis and prevention of fracture. Am J Med; 82 : 68-72.
[39]. Van Der Stelt PF and Geraets WGM. Use of the fractal dimension to describe the trabecular pattern of osteoporosis. J Dent Res.1990;69:287
[40]. Yasar F and Akgunlu F. Fractal dimension and lacunarity analysis of dental radiographs. Dentomaxillofacial Radiology. 2005;34 (5):261.
[41]. Sogur E, Baks B G, Gr€ondahl H-G, and B. Hakan Sen B H. Pixel Intensity and Fractal Dimension of Periapical Lesions Visually Indiscernible in Radiographs. J Endod. 2013;39:16–19
[42]. Chen SK and Chen CM. The effects of projection geometry and trabecular texture on estimated fractal dimensions in two alveolar bone models. Dentomaxillofac Radiol 1998;27:270–4.
[43]. Southard TE, Southard KA, Jakobsen IR, Hillis SL, Najim CA. Fractal dimension in radiographic analysis of alveolar process bone. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1996;82:569-76.
[44]. Pornprasertsuk S, Ludlow JB, Webber RL, Tyndall DA, YamauchiM. Analysis of fractal dimensions of rat bones from film and digital images. Dentomaxillofac Radiol. 2001;30:179-83.
[45]. Raghav N, Reddy S S, Giridhar A G, Murthy S, Yashodha Devi B. K, Santana N, Rakesh N and Kaushik A. Comparison of the efficacy of conventional radiography, digital radiography, and ultrasound in diagnosing periapical lesions.Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110:379-385
[46]. Demirbas AK, Ergün S, Güneri B, Aktener BO and Boyacıoglu H. Mandibular bone changes in sickle cell anemia: fractal nalysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod.2008;106: 41-48
[47]. Teixeira R C, Cassia Maria Fischer Rubira C M F, Assis G F, José Roberto Pereira Lauris J R P, Tania Mary Cestari T M, Izabel Regina Fischer Rubira-Bullen I R F. Radiological and histopathological evaluation of experimentally-induced periapical lesion in rats.J Appl Oral Sci.2010;www.scielo.br/jaos.