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Fractal Analysis of Trabecular Bone of Mandibular Third Molar Region- A Original Research

Dental Science

KEYWORDS : Digital Orthopantomogram, Mandibular teeth, Trabacular bone pattern, Fractal analysis.

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ABSTRACT

Aim & objective:
To compare fractal dimension (FD) from digital panoramic radiographs and to correlate FD of trabecular bone pattern in missing, impacted, functional and erupting third molar.

Settings & Designs:
We conducted study in the Department of Oral Medicine And Radiology on digital Orthopantamograph (OPG).

Material & method:
200 samples (OPG) collected from our radiology section of career post graduate institute of dental sciences and hospital, Lucknow and divided into different groups that are impacted, missing, functional and erupting molars. In this study region of interest (ROI) was arbitrary selected i.e. trabecular bone pattern of 38 region in digital orthopantamograms. ROI was selected and cropped with the help of Microsoft picture manager and fractal analysis done using by ImageJ software.

Statistical analysis used:
In this study student's t test was performed and statistical analysis done. The data were analyzed in mean values, SD, SE, p respectively for different groups.

Results:
The results from all groups were tabulated and the data was analyzed. We compared each group with other three groups respectively. Fractal dimension came out to be significantly variable for all the groups.

Conclusion:
We suggest that the fractal dimension acquired from the panoramic radiograph may be a useful predictor of the tooth eruption pattern. In our study, the results are significant and encouraging but more studies required for exploring and applying in forensic odontology.

Introduction

Fractal analysis is a method for describing complex shapes and structural patterns and is expressed numerically as fractal dimension (FD).[1] Bone texture analysis provides information about bone structures in a noninvasive manner. Mathematical morphology image processing is one method that has been shown useful for bone texture analysis.[2-6] The use of FD to describe the structure of trabecular bone has been described.[7-12] The assessment of trabecular bone structure has many diverse and important applications spanning several fields in medicine. A quantitative, accurate and reliable method for measuring trabecular bone structure has been the focus of a large body of research and the validation of some of these methods could prove to have substantial clinical utility.[13]

Mandelbrot [14] in 1977 brought the concept of `fractals' to the attention of a general audience. He identified families of shapes comprising curves, surfaces, disconnected `dusts' and odd shapes. He coined the term `fractal' from the Latine adjective `fractus', meaning `broken'. Mandelbrot's famousbook [14] is artistic, rather than scientific, connecting mathematical research with natural sciences and computing science. Complex images can be created by means of simple rules combined with fractal geometry. This implies that fractal geometry can be a powerful descriptor of textures in images. The inverse step, of determining the fractal dimension of a given texture, is much more complex. In the eighties, the concepts of fractal geometry were taken up by many branches of science and entered dental radiography from an interest in image pattern recognition and medical imaging.[15] The assessment of trabecular bone structure has many diverse and important applications spanning several fields in medicine. A quantitative, accurate and reliable method for measuring trabecular bone structure has been the focus of a large body of research and the validation of some of these methods could prove to have substantial clinical utility. The premise for using trabecular bone structure in assessing bone health is based on the fact that it is much more metabolically active and has a significantly higher turnover rate than compact bone.[16]

Aim and objective

To compare fractal dimension (FD) from panoramic radiographs and to correlate FD with alveolar bone pattern in missing, impacted, functional and erupting third molar.

Material and method

The study was conducted in the department of Oral Medicine and Radiology, Career Post Graduate Institute of Dental Sciences and Hospital, Lucknow. In this study 200 digital OPGs were taken with same age group (20-45) and region of interest including trabecular bone pattern was selected of 38 region and equally distributed into four group. The analysis and procedure was done using software as described in previous studies on fractal.[17]

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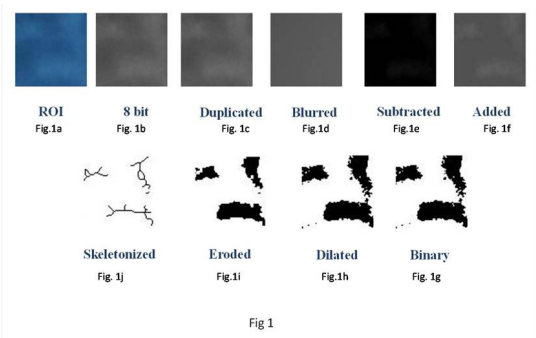

Fig 1

Region of interest [Figure 1a] of 70X120 pixels size was cropped using Microsoft office picture manager software. This image of RGB scale or different bit image scale converted into 8 bit scale image [Figure 1b] because only 8 bit image can be analyzed by this software. From this 8 bit image duplicate image [Figure 1c] prepared and blurred with Gaussian blur 20 [Figure 1d] which removed all fine scale or medium scale structures and retain only large variations in density. The blurred image was then subtracted from the original 8 bit image and founded subtracted image [Figure 1e] and 80 (the define numerical value) was added at each pixel size [figure 1f], this generated an image with a mean value of 80, regardless of the initial intensity of the image. The aim of this operation was to reflect individual variations in the image such as trabeculae and marrow spaces. This added image was converted into binary image [Figure 1g] which contains white and black regions. Black region denotes trabecular portion of bones. If we see this image in magnified view then the interface of the bone marrow and trabecular portion contains small boxes shaped regions which are calculated by box counting method in fractal analysis. Further the binary image was dilated using tool for dilation [figure 1h] and then obtained image was eroded [figure 1i]. This dilation and erosion process reduces the image noise. Last step was to convert the eroded image into skeletonized image [figure 1j]. The skeletonized image was ready for analysis using box counting method. Fractal box count [figure 2] number was made and then a graph was plotted using box count. The box sizes and the slope of the graph denotes fractal dimension [figure 2].[18] The fractal dimension of the radiograph were compared and charted.

Results & discussion:

Panoramic radiographs of 200 patients and divided equally into four groups, Developing (group 1), Impacted (group 2), Functional (group 3) and Missing (group 4) and compared each other. The result of all panoramic was tabulated and the data was analyzed by the student's t test. The data were analyzed in mean values, SD, SE, p respectively. When we compared Developing (group 1)) to Impacted (group 2), the values came out to be; 1.16259, 0.29084 and 0.06347 and Impacted (group2) 1.42165, 0.09726 and 0.01245; (p 0.00031) p value was <0.005 that was significant respectively (table 1a). When we compared developing (group 1) values 1.3696, 0.09425, 0.02107 and Functional (group 3) values 1.369.6, 0.09425, 0.02107 p value 0.0029 (table 1b). When we compared to Developing (group 1)1.16259, 0.29084 and 0.06347 and missing (group 4) 1.47821, 0.06786, 0.02565, p value came out to be >0.005(5.0) that was not significant (table 1c). We compared impacted (group 2) 1.42165, 0.09726, 0.01245 to developing (group 1) values 1.42165, 0.09726 and 0.01245, p value came out to be <0.005 (0.00031) that was significant (table 2a).When we compared impacted (group 2) and functional (group3) values respectively 1.42165, 0.09726, 0.01245 and 1.369.6, 0.09425, 0.02107, p value came out to be >0.005(0.01951) that is non-significant (table 2b). When we were compared Impacted (group 2) and (Missing (group 4), mean standard deviation and standard error values respectively 1.42165, 0.09726, 0.01245 and 1.47821, 0.06786, 0.02565, p value came out to be >0.005 (0.03909) (Table 2c) that was non-significant.When we compared functional (group 3) and developing (group 1) values respectively 1.369.6, 0.09425, 0.02107 and 1.16259, 0.29084, 0.06347, p value came out to be <0.005(0.00249) that was significant (table 3a). We compared Functional (group 3) and Impacted (group 2) values are 1.369.6, 0.09425, 0.02107 and 1.42165, 0.09726, 0.01245, p value came out to be <0.005(0.001951) that was significant. (Table 3b) When we compared functional (group 3) and missing (group 4) values respectively 1.369.6, 0.09425, 0.02107 and 1.47821, 0.06786, 0.02565, p value came out to be <0.005(0.00254) that was significant.(table 3c), When we compared Missing (group 4) and developing (group 1) values respectively 1.47821, 0.06786, 0.02565 and 1.16259, 0.29084, 0.06347, p value came out to be >0.005 (5.0) that was non-significant. (Table 4a) When we compared missing (group 4) and impacted (group 2), values respectively 1.47821, 0.06786, 0.02565 and 1.42165, 0.09726, 0.01245, p value came out to be >0.005 (0.03909), that was non-significant. (Table 4b) We compared missing (group 4) and functional (group 3), values are 1.47821, 0.06786, 0.02565 and 1.369.6, 0.09425, 0.02107, p value came out to be <0.005(0.00254) that was significant. (Table 4c)

Discussion

Radiographic techniques alter the quality of radiographs. One study which compared various parameters used for the radiographic techniques like changes in voltage, pulse, angulations and non standardized radiographic techniques concluded the effect of fractal analysis by the changes and could be more reliable for alveolar bone studies for bone disorders.[19] Various methods are available for the fractal analysis of trabecular bone and rely on fractal properties of trabecular bone. The study emphasized each and every step important to obtained accurate and reliable results.[19] Studies done on patients of osteoporosis,[20] hyperparathyroidism[21] showed fractal dimension analysis was highly successful in distinguishing between radiographs of osteoporotic and non-osteoporotic bone and alveolar bone demineralization in hyperparathyroidism respectively. The fractal dimension analysis of the bone tissue has been introduced as an alternative method to investigate the quality of the alveolar bone.[22]

Trabecular alveolar bone is complex interconnection of trabeculae varying in thickness and orientation. Non-invasive methods to evaluate bone have structure have mostly focused on the interpretation of radiographic projections of the three dimensional structure as two dimensional images. In this study, one such method, fractal dimension analysis was applied to orthopantamograms (OPG).

Conclusion:

We took this concept of self similarity for trabecular bone architecture. As we know forensic dentistry has a very important role in investigation Radiographs are one of the important ante mortem data that can be used for identification of individual Radiographs play key role in dental treatment and routinely OPG being taken for the investigation, diagnosis and surgical and non-surgical treatment planning. Thus if we get a radiograph containing the some region of interest as that in the ante mortem radiograph then by using fractal analysis we can compare data and determine whether radiographs are of same individual the concept of self similarity for trabecular bone architecture has been used for the first time in our study, the results are

significant and encouraging but more studies required for exploring and applying in forensic odontology.

Tables

Table 1a

	Group 1(Developing)	Group 2 (Impacted)
Mean	1.16259	1.42165
Standard deviation	0.29084	0.09726
Standard error	0.06347	0.01245
P value	0.00031	

Table 1b

	Group 1(Developing)	Group 3(Functional)
Mean	1.16259	1.36906
Standard deviation	0.29084	0.09423
Standard error	0.06347	0.02107
P value	0.0029	

Table 1c

	Group 1(Developing)	Group 4 (Missing)
Mean	1.16259	1.47821
Standard deviation	0.29084	0.06786
Standard error	0.06347	0.02565
P value	5.0E-5	

Table 2a

	Group 2 (Impacted)	Group 1(Developing)
Mean	1.42165	1.16259
Standard deviation	0.09726	0.29084
Standard error	0.01245	0.06347
P value	0.00031	

Table 2b

	Group 2 (Impacted)	Group 3(Functional)
Mean	1.42165	1.36906
Standard deviation	0.09726	0.09425
Standard error	0.01245	0.02107
P value	0.01951	

Table 2c

	Group 2 (Impacted)	Group 4 (Missing)
Mean	1.42165	1.47821
Standard deviation	0.09726	0.06786
Standard error	0.01245	0.02565
P value	0.03909	

Table 3a

	Group 3(Functional)	Group 1(Developing)
Mean	1.36906	1.16259
Standard deviation	0.09425	0.29084
Standard error	0.02107	0.06347
P value	0.00249	

Table 3b

	Group 3(Functional)	Group 2(Impacted)
Mean	1.36906	1.42165
Standard deviation	0.09425	0.09726
Standard error	0.02107	0.01245
P value	0.001951	

Table 3c

	Group 3(Functional)	Group 4 (Missing)
Mean	1.36906	1.47821
Standard deviation	0.09425	0.06786
Standard error	0.02107	0.02565
P value	0.00254	

Table 4a

	Group 4 (Missing)	Group 1(Developing)
Mean	1.47821	1.16259
Standard deviation	0.06786	0.29084
Standard error	0.02565	0.06347
P value	5.0E-5	

Table 4b

	Group 4 (Missing)	Group 2(Impacted)
Mean	1.47821	1.42165
Standard deviation	0.06786	0.09726
Standard error	0.02565	0.01245
P value	0.03909	

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Table 4c

	Group 4 (Missing)	Group 3(Functional)
Mean	1.47821	1.36906
Standard deviation	0.06786	0.09425
Standard error	0.02565	0.02107
P value	0.00254	

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