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Digital Imaging Analysis with Fractal Dimension in Oral Leukoplakia

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Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CUR and AF managed the analyses of the study. Author RS managed the literature searches. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Introduction: Complex geometric structures can be quantified by fractal analysis by generating a fractal dimension (FD), thus it can also measure the complexity of mucosa such as oral leukoplakia and other potentially malignant disorders.
Aim: The study was done to perform the fractal analysis (FA) of oral mucosa in Oral leukoplakia, and to calculate its fractal dimension.
Materials and Methods: 10 patients with clinically and histopathologically confirmed oral leukoplakia are analyzed through FA using box counting method in both pre treated and post treated cases.
Results: The present study shows difference between fractal dimension in pre treated and post

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treated cases, and found to be statistically significant [0.05] suggesting that FA is useful tool in predicting the prognosis of oral leukoplakia.
Conclusion: The idea of fractal geometry is simple, and with a simple digital image analyzer, one can measure FD in oral leukoplakia.

Keywords: Oral leukoplakia; fractal dimension.

1. INTRODUCTION

Many fields in science demand the assessment of the degree of complexity of the analyzed areas. The tool which is required to assess this complexity is fractal analysis. Fractal analysis is the process of information processing, where the input data is an image. The word fractus means “broken” or “partial” [1]. In 1983, Mandelbrot A introduced Fractal analysis (FA) [2]. A rough geometric figure which is called as fractal possesses 2 properties, self similarity and fractal dimension. Self similarity is the property of invariance under a change of scale hence magnified images is indistinguishable from the unmagnified images. Second, fractals have fractal dimension [FD]. Fractal geometry is a powerful tool for describing the irregular but ordered shape of many natural objects [2]. Image analysis is used in areas such as materials science (evaluation of porosity, grain size), medicine, forensics (comparison of fingerprints), remote sensing (satellite and aerial images), quality control [3]. In dentistry the calculation of the fractal dimension can be a tool for the early detection of periapical lesion on basic X-rays [4]. In this study, fractal analysis was applied to describe the complexity of potentially malignant disorders like oral leukoplakia by generating FD and to compare this FD before and after treatment of oral leukoplakia to evaluate the prognosis of the lesion.

1.1 Aims and Objectives

Aim of this study was to evaluate the FDs using FA in both pre treated and post treated cases of oral leukoplakia. To introduce FA as a parameter for numeric expression in the prognosis of oral leukoplakia.

2. MATERIALS AND METHODS

The proposed research was submitted to the institutional board of review and ethical clearance was obtained. This study was conducted in the department of Oral Medicine and Radiology after obtaining informed consent from the participants. A total of 10 male patients were included in the study with age of above 18 years under the following criteria.

2.1 Inclusion Criteria

Subjects consenting for biopsy procedure, Clinically evident oral leukoplakia (homogenous type) in buccal mucosa [Fig. 1A].

2.2 Exclusion Criteria

Patients who have taken prior treatment for oral leukoplakia
Non homogenous leukoplakia and other sites such as tongue
For the diagnosis of clinically evident leukoplakia, the following criteria were followed,
A white well-demarcated plaque with surface texture varying from a smooth and thin to cracked mud appearance, non scrapable, and nontender on palpation
All the cases were subjected to incisional biopsy for the histopathological confirmation [Fig. 1B] and the following microscopic criteria was followed for the epithelial dysplasia;

1) Irregular epithelial stratification,
2) Hyperplasia of basal layer,
3) Drop shaped rete processes,
4) Keratinization of single cells or cell groups in the prickle layer,
5) Loss of intercellular adherence,
6) Increased mitotic activity with occasional abnormal mitosis,
7) Increased nuclear-cytoplasmic ratio,
8) Loss of polarity of basal cells,
9) Cellular pleomorphism,
10) Nuclear pleomorphism, and
11) Enlarged and/or multiple nucleoli.

Digital images of lesion along with surrounding healthy mucosa [Fig. 2A] were taken with Canon 700D [18MEGAPIXELS]. The images were cropped involving both healthy and keratinized mucosa within the regions of interest (ROIs) of size 86 × 124 pixels. Using Image J software version 1.47 compatible with personal computer

with a configuration including Windows 7 operating system Intel core i3 CPU, and 64 BIT operating system, the digital images were processed and analyzed. 16-bit direct digital images, were converted to 8-bit images [Fig. 2B], duplicated and blurred by a Gaussian filter with diameter 35 pixels [Fig. 2C]. This is a step to retain only larger variations in density and to remove all the fine-scale and medium-scale structures. The resultant blurred image was then

Fig. 1A. Oral leukoplakia on left buccal mucosa

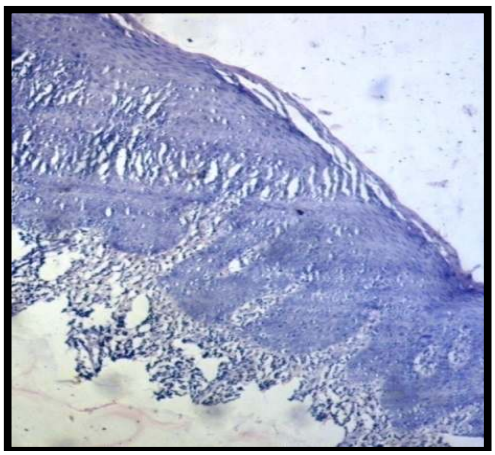

Fig. 1B. Oral leukoplakia at 4x magnification [H&E Stain]

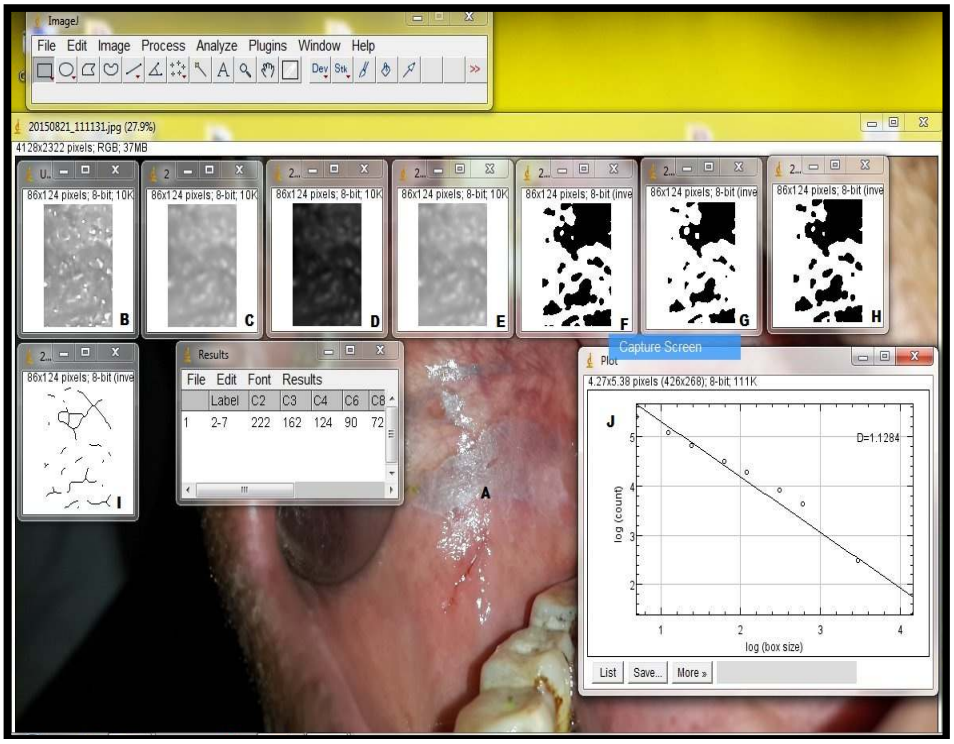

Fig. 2. Steps involved in image processing in fractal analysis: (A) Digital image of buccal mucosa of a patient diagnosed with oral leukoplakia (B) Cropped image converted into 8-bit image (C) Blurred image obtained by adding Gaussian filter with a diameter of 35 pixels (D) Subtracted image (E) Added image, with brightness value of 128 at each pixel location (F) Binary image (G) Eroded image with reduced noise (H) Dilated image (I) Skeletonized image (J) Plot between box count and box size, showing the value of fractal dimension

Subtracted [Fig. 2D] from the original and 128 was added [Fig. 2E] at each pixel location. The image was then made binary [Fig. 2F] thresholding on a brightness value of 128. In order to reduce noise, binary images were eroded [G] and dilated [Fig. 2H] once and processed as skeletonized image [Fig. 2I] Using box counting method the FD of all skeletonized images obtained from the image processing procedure was calculated. A graph plotted between box count and box size showed the resultant FD value [Fig. 2J].

Once the pretreated images of oral leukoplakia were taken, incisional biopsy was done to confirm the diagnosis histopathologically. Patients were advised to quit the habit, and were prescribed Lycopene 8 mg [carotenoids] once daily for a period of 3 months and reviewed at the end of every month. Post-treated images were taken after 6 months from the time of initial treatment, the same procedure using image J software was followed as mentioned in Fig. 2 and fractal dimension values are obtained.

3. RESULTS

Digital images were taken during pre treatment and post treatment for each individual. Fractal dimensions values for pretreated and post treated cases were recorded separately. The information collected regarding all the selected cases were recorded in a Master Chart. Data analysis was done with the help of computer using SPSS statistical package-version 17. A 'p' value less than 0.05 is taken to denote significant relationship. The results of all 10 patients were tabulated [Table 1] and statistical analysis was done using the paired *t* test. Confidence interval was 95%. Kappa statistics for Intra observer reliability was found to be 0.9. Comparison of fractal dimension values among the pretreated and post treated cases as shown in Table 1 reveals, decrease in fractal dimension values after treatment. Table 2 reveals Mean, standard deviation and standard error of deviation. The mean difference between the two groups was found to be 0.3804 and thus by conventional criteria, this difference is considered to be statistically significant p-0.003. This significant difference in FDs between pretreated and post-treated lesions, suggest that with the help of fractal analysis tool, decrease in keratinization of lesion was measured, which signifies outcome of patients following treatment was improved.

Table 1. Value of fractal dimension of 10 patients in pretreatment and post-treatment groups

Pre treatment	Post treatment
0.9274	0.6720
1.1284	0.8614
1.1640	0.5978
0.9957	0.6045
0.9445	0.5102
0.9279	0.6510
1.1460	0.9067
1.1540	0.6034
0.9899	0.6021
0.9344	0.5069

Table 2. Mean value, standard deviation, and no. of samples

Group	Group 1	Group 2	P value
Mean	1.032	0.6516	0.003
SD	0.1036	0.1334	
SEM	0.032	0.0422	
n	10	10	

4. DISCUSSION

Fractal analysis is a method for quantifying complex structures by the study of variation in the image pixel intensity. Through the application of fractal analysis, studies have been done in various parts of the body to characterize lesions and differentiate them from normal [5]. Fractal geometry explains that natural objects are often rough, are not well described by the ideal constructs of Euclidean geometry of points, straight angles, rectangles, and cubes. Fractal geometry has an important property of “self-similarity”, they look alike at all levels of magnification or scale. As a fractal image is viewed at higher and higher magnifications, the amount of detail is constant [2]. Oral Leukoplakia has high malignant potential; assessment of its progression is of great significance. In the present study, since the keratinisation increases the complexity of mucosa in oral leukoplakia, fractal analysis was applied and its fractal dimension was calculated before and after treatment of each individual and compared. The mean value of FD of pretreated cases was 1.032, and for post treated cases was 0.6516, which reveals there was a decrease in FD. This decrease in FD also conveys that there is decrease in complexity of oral mucosa [regression] in oral leukoplakia following treatment. It is often difficult to assess the prognosis of potentially malignant disorders;

hence application of fractal analysis can serve as a valuable tool to assess the prognosis of lesion.

PB Pandey et al. [6] used fractal analysis to measure fractal dimension of oral leukoplakia in 50 pretreated and postreated cases. When the values were compared, he found significant decrease in FD of postreated cases. FD analysis was introduced by him for the first time as an alternative method to investigate the prognosis of the leukoplakia lesions.

Kąkolewska's research obtained a correlation between the implants primary stability and the fractal dimension, the primary stability of implants is high when FD is low [1].

By studying the complexity of the epithelial - connective tissue interface in oral cancer, fractal dimension can be used as a quantitative index to discriminate among normal, dysplastic and neoplastic oral mucosa. Landini and Rippin [7] in their study, showed that the increase of abnormalities was followed by an increase of fractal dimension.

The concept of fractal geometry is simple, and with a simple digital image analyzer, one can measure FD of the object of interest. One has to be computer literate and well acquainted with the field of mathematics for calculation and interpretation of fractal geometry. The Strength of this study is through application of FA, evaluation of different treatment outcomes at a stipulated period can be established. Assessment by FA also saves time. Though the results supports the literature, smaller sample size is the major limitation, also FA needs to be widely applied among other potentially malignant disorders to identify its use. In the future, fractal geometry will probably help in classifying different diseases, differentiating benign and malignant cells, quantifying fibrosis and angiogenesis, and understanding tumorigenesis [2].

5. CONCLUSION

Further research with more sample size can achieve more significant result. This procedure is economical, non-invasive and proves as a helpful chair side adjuvant tool in oral leukoplakia prognosis.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Leszczyński P, Sokalski J. The use of fractal analysis in medicine. Dent Med Probl. 2017;54(1):79–83.
2. Dey P. Basic principles and applications of fractal geometry in pathology: A review. Anal Quant Cytol Histol. 2005;27:284–290.
3. Gawlik J, Magdziarczyk W, Wojnar L. Fractal analysis of geometric surface structure. Komputerowo Zintegrowane Zarządzanie. 2011;2:382–396. [In Polish]
4. Huang CC, Chen JC, Chang YC, Jeng JH, Chen CM. A fractal dimensional approach to successful evaluation of apical healing. Int Endod J. 2013;46:523–529.
5. Deepak P. Fractal analysis in grading of oral leukoplakia. IJOART. 2015;4(9):26-36.
6. Pandey PB, Kandakurti S, Saxena VS, Tripathi P, Pamula R, Yadav M. Fractal analysis in oral leukoplakia. J Indian Acad Oral Med Radiol. 2015;27:354-8.
7. Landini G, Rippin JW. Fractal dimensions of the epithelial— connective tissue interfaces in premalignant and malignant epithelial lesions of the floor of the mouth. Anal Quant Cytol Histol. 1993;15(2):144-9.

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