Accuracy of Volume of Interest Determination with Cone-Beam Computed Tomography in Periodontitis due to Psychological Stress

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Abstract

The main etiological factor of periodontal disease is bacteria which substantially protect the human oral cavity. Periodontal disease is primarily characterized by inflammation. Psychological stress causes periodontitis resulting in a widening of the periodontal ligament which will form a gap that will be analyzed by Volume of Interest (VOI) with Cone-beam Computed Tomography (CBCT).

Treatment of male Wistar for 5 months with moderate running and fear of predators and decapitations on days 1 and 5 for CBCT testing and VOI analysis on the left maxilla. Cortisol is a steroid hormone whose levels can be affected by psychological stress is the cause of periodontal disease. To investigate the accuracy and reproducibility of landmarks and measurements marked on images obtained from CBCT. CBCT analyzes and determines VOI by determining 4 components, namely Tissue Volume (TV), Percent Bone Volume (BV / TV), Tissue Surface (TS), and Bone Surface Density (BS / TV). The moderate running group showed an increase in VOI by 94% and the fear group for predators by 18%, this is when compared to the control group who had a VOI of -0.65%. This VOI determination can analyze the affected areas of psychological stress that cause periodontitis.

The accuracy of CBCT is still possible in determining VOI from periodontitis caused by psychological stress. The CBCT determination of VOI in maxillary periodontitis is very accurate for the psychological consequences of stress.

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Introduction

Germline-coded pattern recognition receptors (PRRs) are closely related to the innate immunity response based on their recognition of pathogens such as bacteria and viruses. The inflammasome consists of multimeric protein structure, sensor molecule (PRR) and adapter molecule associated with apoptotic proteins due to the content of the caspase recruitment domain (CARD) and the protease caspase-1. There are several inflammations that can be formed such as PRR sensor which induces activation.[1,2]

The presence of endogenous and exogenous stimuli in the body causes a physiological response in the form of inflammation of the immune system. This inflammation is in the form of an acute response which can then turn into a chronic one when the adaptive immune response is activated.

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Periodontal diseases such as gingivitis and periodontitis are often caused by bacteria in the human oral cavity so that they often stimulate inflammation. [3-6] Periodontitis is generally associated with infection of the supporting tissues of the teeth (periodontium) which is characterized by a high inflammatory response. In addition, periodontitis is common in 10% - 15% of the adult population. Genetic factors, environment, unhealthy lifestyle, and exposure of individuals affected by the onset also play a role in the occurrence of periodontitis. [7-11]
Recently, stress has contributed to periodontal disease due to its physiological and psychological effects on periodontitis sufferers.[12]

Disease disorders caused by stress should be monitored globally because stress has been shown to alter the biochemistry, local periodontal microenvironment and inflammatory burden. global systemic.[13] Chronic periodontitis is often caused by psychological stress.[14] The use of unhealthy lifestyles such as smoking, consuming alcohol, and staying up late also contributes to aggravating dental periodontitis and other risk factors for oral diseases such as dental caries and oral cancer. [15-17] The stress hormone cortisol directly induces changes in the gene expression profile of the oral microbiome that reproduce the results found in the expression profile of periodontal disease and its development. [18]

Psychological stress causes periodontitis, resulting in widening of the periodontal ligament, which forms a fissure. This gap was analyzed by volume of interest (VOI) to determine the level of damage caused by psychological stress on the periodontal ligament. Measurement of VOI using 3D Cone-beam computed tomography (CBCT) imaging. Dental diagnosis using CBCT routinely includes the diagnosis of dental implantology, orthodontics, periodontics, maxillofacial traumatology and surgery, endodontics, and temporomandibular joint (TMJ). In detail, the tooth structure, maxillofacial and anatomical structures can be visualized 3D with CBCT.[19]

The smallest structures can be analyzed in the gaps in the periodontal, so CBCT is a tool used in diagnosing periodontal disease and for planning treatment.[20,21]

Materials and methods

The in vivo test was carried out using male Wistar rats aged 5 months (300 grams) then treated with running with moderate exercise, namely 14-16 m / min, equivalent to 65-70% VO2 max 49, using a treadmill for 15 minutes with rest for 45 minutes continued, the animal tried to run for 15 minutes continuously and continued for 1 day and 5 days and the fear treatment group by bringing the experimental animal closer to the cat as a rat predator for 1 day and 5 days (Figure 1). All the procedures involving animals have been reviewed and approved by IPB University, Bogor, Indonesia on Ethical Clearance Number: 019/KEH/SKE/XI/2020.

Figure 1. Sample with moderate running treatment (A), fear treatment of predators (B).

Samples were terminated on day 1 and day 5 followed by decapitation which was previously anesthetized with ketamine 95 mg/kg BW intramuscularly and xylazine 5 mg/kg BW intraperitoneally then put into 10% buffered formaldehyde solution for fixation before the CBCT test samples. The sample was placed in a container given wax as the fixation of the sample when it was scanned in a rotation of 3600 CBCT (CS 9000 3D, NY USA). CBCT was conducted at Arrmy Hospital, Gatot Subroto Army Hospital, Jakarta. The position of the specimen was adjusted in such a way that it was placed in a place that was fixed with wax and then scanned with a rotation of 3600 with a CBCT (CS 9000 3D, NY USA). The specimen is placed in a position where ABC on the lingual and buccal sides is parallel (red line in the X-Z plane). In addition, the position is arranged in such a way that from anterior to posterior it is parallel to the height of the tooth crown (red line in the Z-Y plane) The X-Y plane image is then rotated. The image analyzed is a pile of slices from the X-Z plane. CBCT was performed with Resolution: 0.0131 pixels per micron, Voxel size: 76.5217x76.5217x1 micron^3, Exposure Time: 10800, then reconstructed the image into a 16-bit grayscale image.

Results

The CBCT test was carried out on the sample to analyze the volume of interest so that the left maxillary jaw was determined in the treatment of moderate running (Figure. 2) and fear of predators (Figure. 3). Data were obtained for each by analyzing tissue volume (TV), percent bone volume (BV / TV), tissue surface (TS), and bone surface density (BS / TV) (Figure. 4).

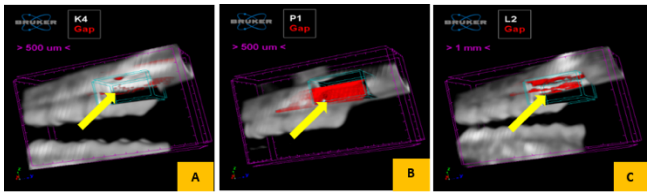

Figure 2. Samples of day 1, control (A), moderate running treatment (B), and fear treatment of predators (C).

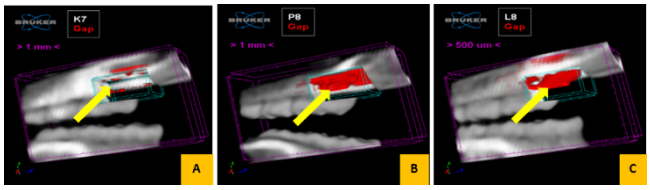

Figure 3. Samples of day 5, control (A), moderate running treatment (B), and fear treatment of predators (C).

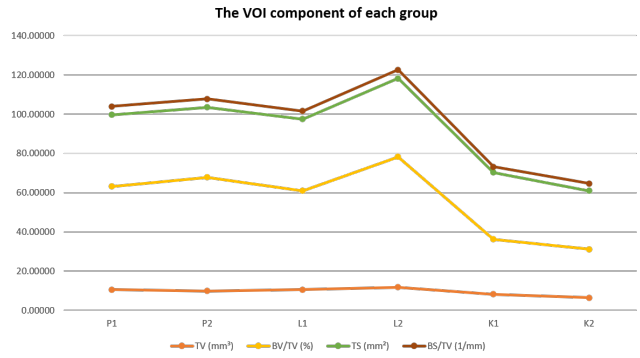

Figure 4. The VOI component of each group.

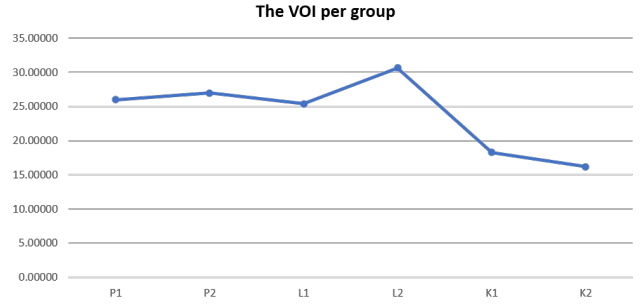

Figure 5. The VOI per group.

Discussion

Adrenal glands are known as the main producer of cortisol, which plays a role in responding to stress or inflammation.[12-15] Meanwhile, the prevalence of periodontal disease is also influenced by psychological stress, so that it can increase inflammatory agents. This increase becomes a relevant benchmark in assessing level of risk of periodontal disease. The existence of a stress-related correlation with periodontal disease was first confirmed during the development of acute necrotizing ulcerative gingivitis. However, currently, there are known data regarding the correlation between psychological stress and chronic periodontal disease.[13,16,17]

Persistent stress tends to have a negative impact on the body's immunological response, resulting in the severity of inflammation. On the oral cavity, cortisol can suppress immune responses such as secretory immunoglobulins and neutrophils, thereby reducing the body's immunity to infection with periodontal microorganisms. Meanwhile, oral microbes are also able to sense the presence of stress conditions in the oral cavity so that it can exacerbate periodontal disease.[18-22] Psycho-social measures of stress manifesting as depression are indicators of a high risk of periodontal disease.[14] Therefore, cortisol levels and psychological stress are positively correlated with chronic periodontitis.[12] Measurement accuracy and reproducibility of landmarks can be obtained from CBCT. [21] Aveolar bone loss is a major symptom of periodontal disease. The use of CBCT can detect performance, estimate accuracy and assess treatment outcomes for periodontal disease. In addition, CBCT is also useful and accurate in diagnosing infa-bone defects and furcation involvement so that it can be used to evaluate the outcome of periodontal surgery and regenerative therapy.[22-24]

3D imaging visualization on CBCT to analyze and determine VOI by determining 4 components, namely TV, BV/TV, TS, and BS/TV. Tissue volume (TV) is the volume of VOI (volume of interest) defined, which covers the gap and also covers a portion of the hard tissue around the gap in mm3.[25-27] Percent bone volume (BV/TV) is the ratio of the volume gap to VOI with units of %. Tissue surface (TS) states the surface area of VOI in mm3, while Bone surface density

(BS/TV) is the ratio of the surface area of the gap to VOI.[28,29] This is generally translated as a trend toward complexity and/or pattern of gap distribution in units of 1/mm (Figure 4). VOI Determination Accuracy by CBCT in Maxillary Periodontitis under Psychological Stress showed that TV, BV/TV, TS, and BS/TV in the moderate running group and predatory fear increased from day 1 and day 5 compared to the control group on day 1. Day 1 and day 5. The moderate running group showed an increase in VOI by 94% and the fear group for predators by 18%, this is when compared to the control group who had VOI of -0.65%, which means that the accuracy of determining VOI is very accurate in periodontitis due to the psychological effects of stress.[30] Increasing the gap by determining VOI so that psychological stress can be assessed can be how much the influence of psychological stress involving the periodontal tissue causes periodontitis.[31,32] This VOI determination can analyze the affected areas of psychological stress that cause periodontitis. The accuracy of CBCT is still possible in determining VOI from periodontitis caused by psychological stress.

Conclusions

The CBCT determination of VOI in maxillary periodontitis is very accurate for the psychological consequences of stress.

Acknowledgments

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Declaration of Interest

The authors state that no conflict of interest in this study

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