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"PROF. DR. PARASKEV STOYANOV" – VARNA CITY
FACULTY OF MEDICINE
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PROSPERITAS VESTRA FINIS NOSTRA!

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PROCALCITONIN AND DELTA NEUTROPHIL INDEX LEVELS IN THE SURGERY OF HEAD AND NECK INFLAMATORY DISEASES

ABSTRACT

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The dissertation contains a total of 104 pages and is illustrated with 49 graphics, 43 tables and 2 diagrams. The bibliographic reference includes 135 literary sources, 2 of them in Cyrillic and 133 in Latin alphabet. The numbers of the graphs in the abstract do not correspond to those in the dissertation.

The study was carried out in the Clinic of Maxillofacial Surgery at University General Hospital (UGH) "Sveta Marina" – Varna city, and the laboratory analysis - in the Central Clinical Laboratory of the same medical institution.

The doctoral candidate works as a medical doctor in the Clinic of Maxillofacial Surgery at University General Hospital (UGH) "Sveta Marina" – Varna city and holds the position of "assistant" in the Department of General and Operative Surgery at the Medical University "Prof. Dr. Paraskev Stoyanov" - Varna city.

The dissertation work was discussed, accepted and referred for defense in front of a scientific jury by Departmental Council No. 8, Department of General and Operative Surgery at the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna city on September 30, 2022.

The public defense of the dissertation work will take place on December 12, 2022 in auditorium No. 103 of the Faculty of Dental Medicine at the Medical University "Prof. Dr. Paraskev Stoyanov" - Varna city.

The defense materials are available in the Library of the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna city, as well as on the official website of the university.

CONTENTS

1. ABBREVIATIONS USED

AB – antibiotic

AK – amino acid

DNA - deoxyribonucleic acid

CAT (CT) - computed axial tomography (computed tomography)

MFS – maxillofacial surgery

RNA - ribonucleic acid

ESR – erythrocyte sedimentation rate

tRNA - transport ribonucleic acid

COPD – chronic obstructive pulmonary disease

MRI - nuclear magnetic resonance

aPTT – activated partial thromboplastin time

CGRP – CT gene related peptide (calcitonin gene related peptide)

CRP – C-reactive protein

CT – calcitonin

CTK – Cytokine

DNI – delta neutrophil index

IG – immunoglobulin

IL – interleukin

INF - interferon

kDa – kilodalton

MELD Score – Model for End-Stage Liver Disease Score

MPO – myeloperoxidase

Neutr – neutrophils

NO – nitric oxide

PAM – peptidylglycine alpha-amidating monooxygenase

PCT – procalcitonin

PMN – polymorphonuclear neutrophil leukocytes (polymorphonuclears)

SIRS – Inflammatory and Systemic Response Syndrome

TNF – tumor necrosis factor

T½ – half-life time

WBC – leukocytes (white blood cells)

2. INTRODUCTION

The range of diseases in the head and neck area is extremely large and their diagnosis often is a challenge for the maxillofacial surgeon. Inflammatory diseases of the face and neck, as the most visible and representative parts of the human body, are one of the most common and of extremely high social and psycho-emotional significances for the patient, and their phlegmonous complications with a protracted and severe course, with a long stay in intensive care units and a doubtful prognosis are some of the conditions that burden the health care system a lot. The known laboratory indicators such as the value of leukocytes, neutrophils, ESR and CRP not always increase their absolute value in the course of the infectious process so that they can be reliable and definitive markers for the diagnosis, treatment, follow-up and prediction of the outcome of inflammatory diseases of the head and neck.

At the end of the last century, it was established that PCT and DNI have a diagnostic value in inflammatory diseases, and a number of studies and experiments began to be conducted in order to clarify their characteristics. They have been studied and analyzed many times in different nosological entities from the domain of internal diseases and surgery. There is no conclusive data, however, on their study in inflammatory diseases of the head and neck.

PCT is one of the most promising biomarkers of inflammation in the diagnosis of infectious diseases. Its increased values in the blood plasma indicate the degree of bacterial inflammation and appear to be an earlier marker for the diagnosis of inflammatory diseases than the classic indicators of inflammation. Data in the literature indicate that PCT as a marker has a very good diagnostic profile in the diagnosis of these diseases. PCT has been defined as an early marker of inflammation, which detects the development of the inflammatory process even before the values of WBC, neutrophils and CRP have increased. However, a number of causes, different than inflammation, can induce increased PCT synthesis. All of this indicates the need for further studies to clarify its predictive value in the diagnosis of inflammatory diseases, which sparked our interest and formed much of the rationale for the present study.

The extraction of data from the already measured values of the total number of leukocytes and neutrophils, which do not always show great informativeness and certainty in the diagnosis of inflammatory diseases, makes it possible to calculate the DNI, which marks

trends and statistically significant correlations in dedifferentiation, treatment, follow-up and predicting the outcome of these head and neck disorders. In its essence, DNI is a calculable indicator available for generation using a specific method of differentiation of leukocyte fractions, namely cytochemical reaction of myeloperoxidase, which is affected by the presence of immature granulocytes in peripheral blood. The latter are the main protective mechanism against the bacterial causes of focal or generalized inflammation in the body. Their presence in the peripheral blood is an expression of increased myeloid cytogenesis and correlates with the severity and severity of the inflammatory disease, respectively. In routine clinical practice, the level of immature neutrophils is one of the criteria in the definition of systemic inflammatory response syndrome (SIRS), sepsis and various other inflammatory localized processes, such as head and neck abscesses, and even in myeloproliferative diseases. In many studies, DNI has been compared with established serum inflammatory markers such as C-reactive protein and procalcitonin, which is the case in the present work. In all sources, the index correlated positively with established inflammatory markers.

In order to establish the clinical applicability of PCT and DNI as indicators of inflammation, it is necessary to evaluate their diagnostic reliability and the effectiveness of their methodologically derived cut-off values in the studied patients with head and neck abscesses of odontogenic and non-odontogenic origin.

3. PURPOSE

The aim of the present work is to determine the diagnostic value of procalcitonin (PCT) and delta neutrophil index (DNI), their predictability, sensitivity and specificity in inflammatory diseases of the head and neck and to analyze their advantages and disadvantages in the diagnostic-therapeutic plan of these diseases relative to already established markers of inflammation such as WBC, neutrophils and CRP.

4. GOALS

To fulfill these goals the following tasks were set:

1. Determination of the average values of PCT, DNI, CRP, WBC and neutrophils in the studied group of patients with head and neck abscesses, the subgroups of patients with odontogenic abscesses, with non-odontogenic abscesses and the control group of healthy people;

2. Determination and analysis of gender differences regarding the studied markers PCT, DNI, CRP, WBC and neutrophils in the studied population;

3. Determination and analysis of correlations between PCT, DNI, CRP, WBC and neutrophils in the studied group of patients with head and neck abscesses, in the subgroups with odontogenic and non-odontogenic abscesses and in the control group of healthy people;

4. Determination of cut-off diagnostic and reference values of PCT and DNI in the studied groups of patients with odontogenic and non-odontogenic abscesses of the head and neck;

5. Determination of sensitivity, specificity and predictability of PCT, DNI, CRP, WBC and neutrophils in the studied group of patients with odontogenic and non-odontogenic head and neck abscesses.

5. MATERIALS

For the period from July 2021 to December 2021, 81 patients with head and neck abscesses were treated in the Maxillofacial Surgery Clinic at the University Multispecialty Hospital for Active Treatment "Sveta Marina" EAD – city of Varna (50 of them with odontogenic and 31 with non-odontogenic origin), in which PCT, CRP, WBC and Neutr values were examined and DNI was calculated. The group included 48 men (59.26%) and 33 women (40.74%) with a mean age of 43 years (42 years for men and 44 years for women).

From all 81 patients, one 80-year-old female patient with non-odontogenic abscess was excluded from the study due to the detection of oncohematological disease.

Regarding the pathology, the remaining 80 patients were divided into two groups – 50 with odontogenic abscesses and 30 with non-odontogenic abscesses. Their gender distribution is 48 (60%) men and 32 (40%) women. Patients had a mean age of 43 years (42 years for men and 44 years for women), ranging from 18 to 84 years. (graphic 1, table 1)

As a control group, 51 healthy subjects (30 men and 21 women) of age and gender corresponding to the studied group were used.

Graphic 1. Distribution of patients in the studied group and its subgroups by number and gender

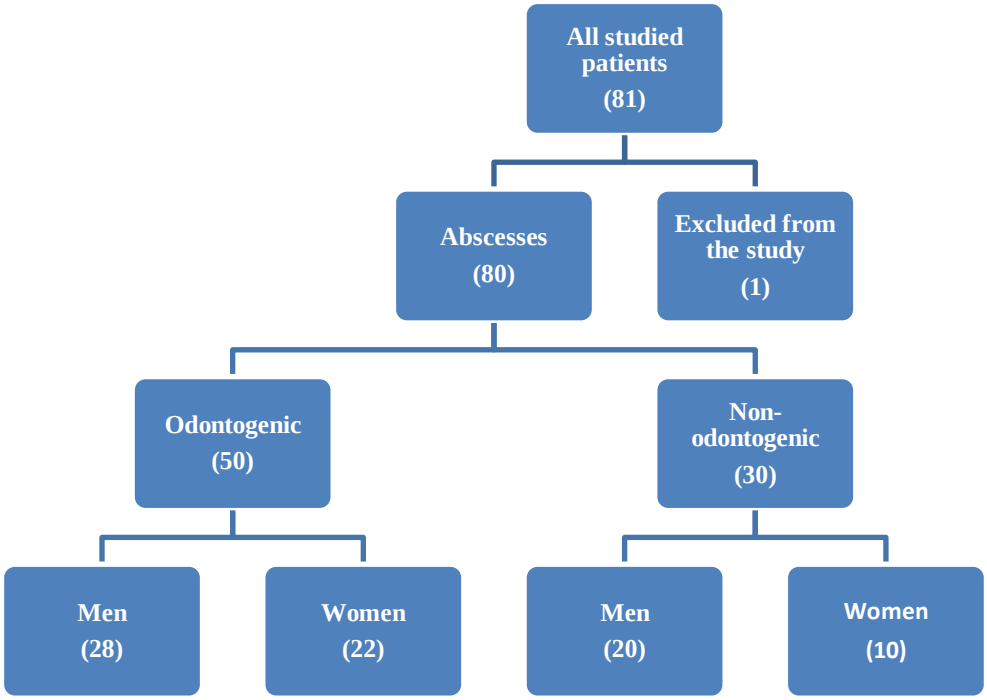


Table 1. Average age of the examined patients in the studied group

	Number	Arithmetic mean	Median	Standard deviation	Minimum age	Maximum age
Men	48	42	42,5	17,48	18	84
Women	32	44	42,5	16,34	18	79
Total	**80**	**43**	**42,5**	**17,2**	**18**	**84**

Patients meeting all of the following criteria (including criteria) were included in the study:

• presence of an abscess or phlegmon in the region of the head and neck, proven during the clinical examination and/or through additional imaging studies such as echography, nuclear magnetic resonance and computed tomography;

• confirmation of the clinical diagnosis during the surgical intervention (incision, lavage, drainage), during which the available exudate is evacuated;

• age over 18 years;

• confirmation by patients that they wish to participate in the study, evidenced by signing an informed consent to this effect.

The study did not include patients with anamnestic data on the following diseases and conditions in which false-positive results are possible (exclusion criteria):

• multiple injuries;

• recent major surgical interventions;

• burns;

• cardiogenic shock;

• overheating;

• parasitic infections;

• systemic mycotic infection;

• known lung carcinoma (including small cell);

• known carcinoma of the thyroid gland (including medullary C-cell carcinoma);

• known tumors with paraneoplastic hormone production;

• prolonged severe organ hypoperfusion;

• conditions and diseases reducing the content of oxygen in the tissues - bronchial asthma, pneumonia, etc.;

• intake of medications that stimulate the release of cytokines.

Tables 2 to 4 show the distribution of studied patients from the studied group by gender and age groups, and graphic 2 shows their distribution according to whether the disease involves the head or the neck.

Table 2. Distribution of the examined patients from the studied group by age groups

Age (years)	Number	Percentage (%)
to 44 (young age)	41	51,25
45-59 (middle age)	26	32,5
60-74 (elderly)	10	12,5
75-89 (old people)	3	3,75

Total	**80**	**100**

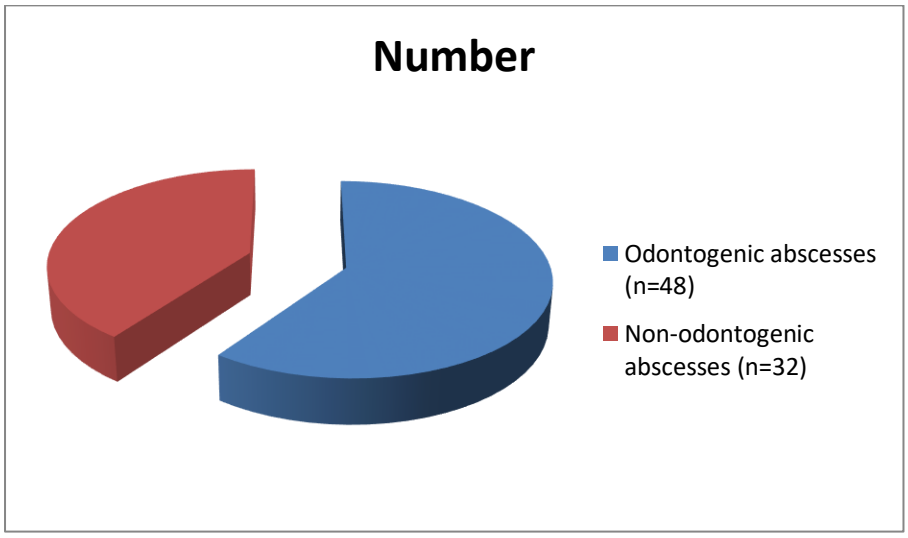
Table 3. Distribution of the examined patients from the studied group by gender

Gender	Number	Percentage (%)
Men	48	60
Women	32	40
Total	**80**	**100**

Table 4. Distribution of the examined patients from the studied group by gender and age groups

Age (years)	Gender		Total
	Men	Women	
to 44 (young age)	25	16	41
45-59 (middle age)	15	11	26
60-74 (elderly)	6	4	10
75-89 (old people)	2	1	3
Total	**48**	**32**	**80**

Graphic 2. Distribution of examined patients from the studied group according to head and neck diseases



5. 1. Patients with odontogenic abscesses

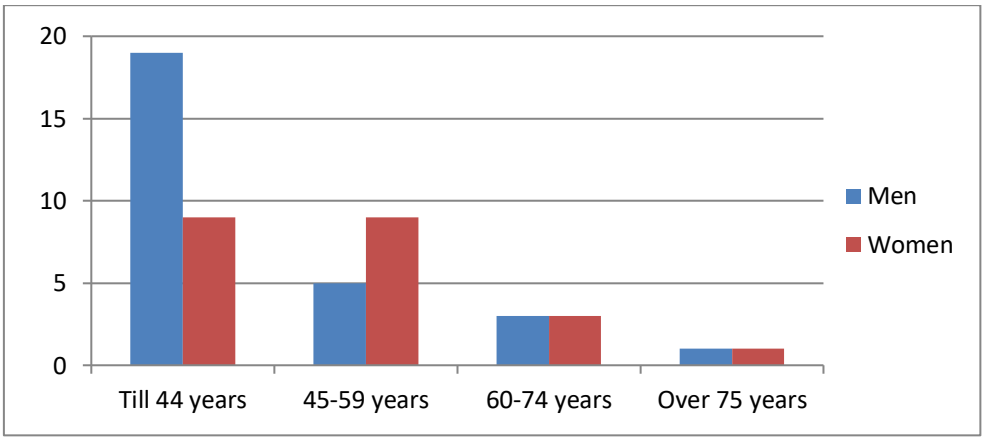
The average age of patients with odontogenic abscesses was 42 years. The youngest patient is 18 years old and the oldest is 79 years old.

Table 5 and graphics 3 and 4 show the distribution of the studied patients from the studied subgroup with odontogenic abscesses by gender, age groups and which jaw segment is affected by the disease.

Table 5. Age of the studied patients with odontogenic abscesses

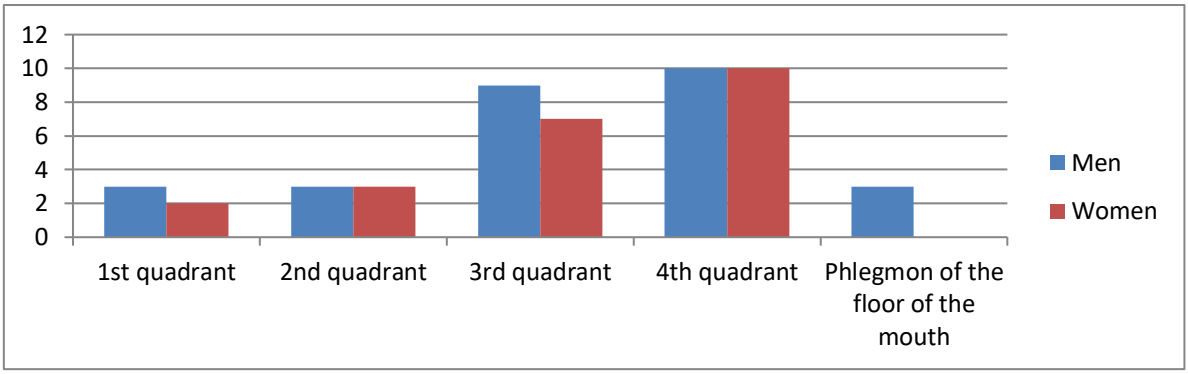
	Number	**Arithmetic mean**	**Median**	**Standard deviation**	**Minimum age**	**Maximum age**
Men	28	38	36,5	17,72	18	78
Women	22	47	46	17,24	18	79
Total	**50**	**42**	**39,5**	**18,2**	**18**	**79**

Graphic 3. Distribution of patients with odontogenic abscesses by age



The most affected are patients in the age range up to 44 years, i.e. those at a young age.

Graphic 4. Distribution of patients with odontogenic abscesses according to the affected jaw segment



The largest number of patients with an etiological factor for the odontogenic abscess are teeth from the fourth jaw quadrant (41-48) – a total of 20 (10 men and 10 women).

In second place are the patients with odontogenic abscesses caused by a tooth in the third quadrant (31-38) – 16 people (9 men and 7 women).

The patients with the etiological factor of the purulent inflammation of the tooth from the second quadrant (21-28) follow - 6 people (3 men and 3 women).

The proportion of patients with odontogenic abscess caused by a tooth from the first quadrant (11-18) is the smallest - a total of 5 people (3 men and 2 women).

The patients with diffuse spread of purulent infiltrate (phlegmon) were 3 men. In all of them, all three lodges from the lower floor of the oral cavity were affected – reg. submandibularis dex, reg. submentalis and reg. submandibularis sin.

5. 2. Patients with non-odontogenic abscesses

The mean age of patients with non-odontogenic abscesses was 45 years, with the youngest patient being 18 years and the oldest being 84 years.

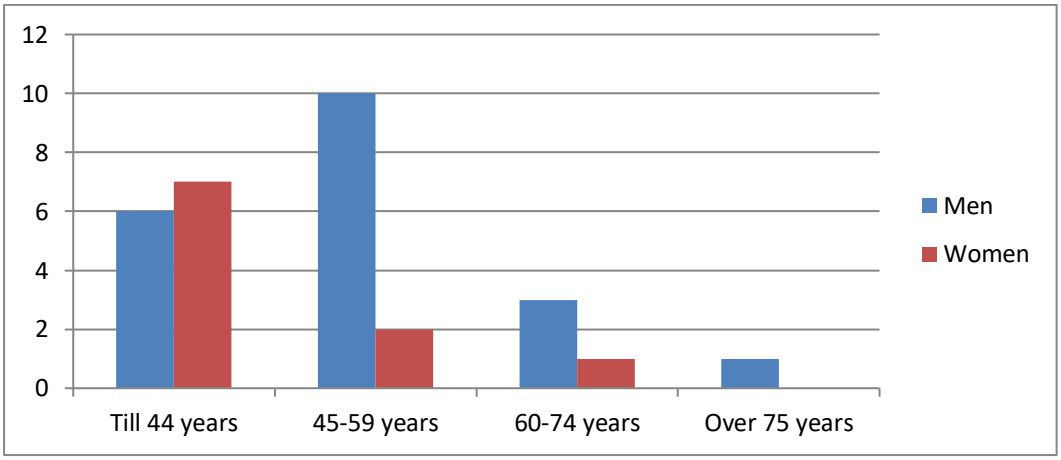
Table 6 and graphics 6 and 7 show the distribution of the studied patients from the studied subgroup with non-odontogenic abscesses by gender, age groups and which part of the

head and neck is affected by the disease.

Table 6. Age of the studied patients with non-odontogenic abscesses

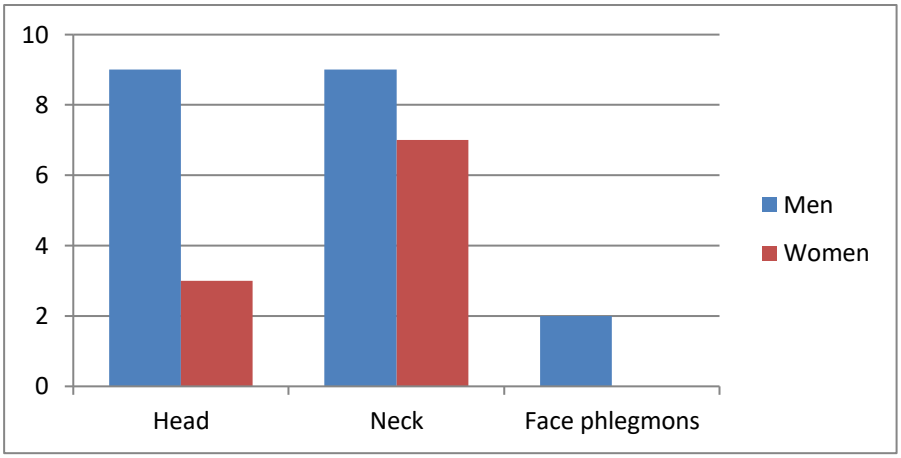
	Number	Arithmetic mean	Median	Standard deviation	Minimum age	Maximum age
Men	20	48	48	15,58	19	84
Women	10	38	36	12,4	18	62
Total	**30**	**45**	**46,5**	**15,5**	**18**	**84**

Graphic 5. Distribution of patients with non-odontogenic abscesses by age



The highest incidence is in the age up to 44 years, i.e. in patients at a young age.

Graphic 6. Distribution of patients with skin abscesses according to the affected part of the head and neck



The more common non-odontogenic abscess in the head and neck area was that of the neck – a total of 16 patients (9 men and 7 women).

In second place are the patients with limited purulent inflammation of the head - a total of 12 people (9 men and 3 women). In all of them, the exudate was in the facial area and there were no patients with purulent pathology involving the capillitium (graphic 6).

The patients with diffuse spread of the purulent infiltrate (phlegmon) are 2 men with face phlegmons - one in the right and the other in the left half of the face.

5. 3. Control group

The control group, consisting of 51 healthy people, has an average age of 43 years – 30 men with an average age of 42 years and 21 women with an average age of 46 years. The youngest individual studied was a 17-year-old female, and the oldest was an 81-year-old male.

Tables 7-10 and graphics 7 and 8 show the distribution of the examined healthy people from the control group by gender and age groups.

Graphic 7. Demographic distribution of patients in the control group

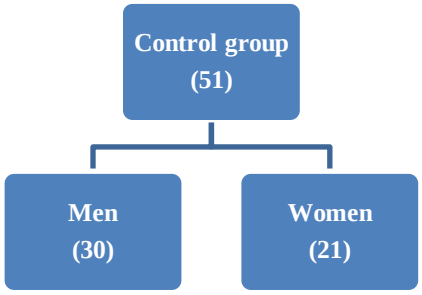


Table 7. Distribution of the examined patients from the control group by gender

Gender	Number	Percentage (%)
Men	30	58,82
Women	21	41,18
Total	**51**	**100**

Table 8. Age of the control group

	Number	Arithmetic mean	Median	Standard deviation	Minimum age	Maximum age
Men	30	42	40,5	14,4	19	81
Women	21	46	48,5	14,54	17	87
Total	**51**	**43**	**43,5**	**14,58**	**17**	**81**

Table 9. Distribution of the examined patients from the control group by gender and age groups

Age (years)	Gender		Total
	Men	Women	
to 44 (young age)	18	9	27
45-59 (middle age)	8	10	18
60-74 (elderly)	3	1	4
75-89 (old people)	1	1	2
Total	**30**	**21**	**51**

Graphic 8. Distribution of patients from the control group by age

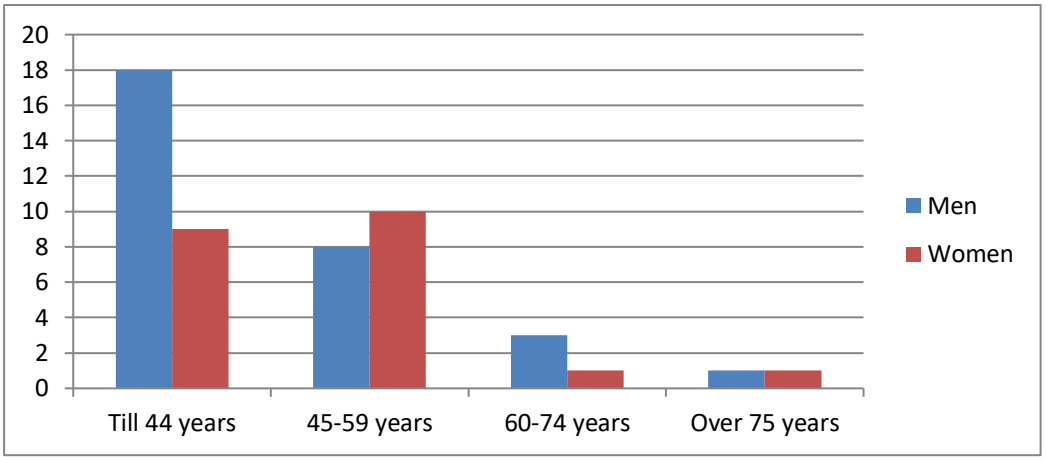


Table 10. Distribution of the examined patients from the studied group by age groups

Age (years)	Number	Percentage (%)
to 44 (young age)	27	52,94
45-59 (middle age)	18	35,3
60-74 (elderly)	4	7,84
75-89 (old people)	2	3,92
Total	**51**	**100**

In the control group, as well as in the two studied subgroups (with odontogenic and non-odontogenic abscesses), individuals aged up to 44 years predominate, i.e. young people.

6. METHODS

6. 1. Technical approach of taking blood for instrumental research

In all patients, blood was collected by nurses from the Maxillofacial Surgery Clinic by venipuncture from the median cubital vein (vena mediana cubiti) in the cubital fossa (fossa cubiti). Venipuncture is a minimally invasive procedure in which a needle is inserted into the vein by piercing it. A rubber band, called a tourniquet, is placed around the armpit of the upper limb, through which the blood flow is stopped. The blood-filled vein protrudes, and this makes it easier to insert a needle into it. In advance, the place from which the blood is taken is disinfected with alcohol. The needle is connected to a disposable blood collection tube (vacutainer) and the latter is filled with blood. After collecting the required amount of blood, the tourniquet is removed. A cotton or gauze pad soaked in alcohol is placed on the needle inserted into the vein, after which it is slowly removed from the vein in the opposite way and the blood is mixed by gently shaking the vacutainer several times. The venipuncture site is pressed for several minutes. The sample is brought to the Central Clinical Laboratory of UMBAL "St. Marina" EAD - city of Varna, where it is processed. The results of all investigated indicators (PCT, DNI, WBC, Neutr and CRP) are presented in numerical form.

6. 2. Processing of the taken venous blood and obtaining a result

The laboratory tests were carried out in the Central Clinical Laboratory at the "Sveta Marina" UMBAL EAD - the city of Varna as follows:

- for CRP on biochemical analyzer "COBAS 6000" ("Hoffmann la Roche") by immunoturbidimetric method with latex particles, and its numerical values were presented in mg/l;

- for WBC on hematology analyzer "ADVIA 2120" ("Siemens"), and its numerical values were presented in Nx109/L;

- for neutrophils on a hematology analyzer "ADVIA 2120" ("Siemens"), and its numerical values were presented in Nx109/L;

- for PCT on biochemical analyzer "ADVIA 1800" ("Siemens") by latex enhanced immunoturbidimetric analysis with reagent kit of "Diazyme Laboratories Inc", and its numerical values were presented in ng/ml;

- for DNI, the differential blood count is determined on an automatic 5 Diff hematology analyzer "ADVIA 2120" ("Siemens") and after its calculation, the results are presented in percentage (%).

6. 3. Criteria for making the diagnosis "abscess"

Certain criteria for making the diagnosis of an abscess are the evacuation of the purulent exudate during the operative intervention and the confirmation of its presence by means of imaging methods - echography (ECHO), nuclear magnetic resonance (NMR), computed axial tomography (CAT or CT).

Criteria leading to the diagnosis are the increased markers of inflammation, obtained by the instrumental methods of examining the blood of the patients.

6. 4. Statistical evaluation of the data and

graphical representation of the results

Column graphics with clusters, pie charts with individual segments in 3D and SmartArt graphics of the software program "Microsoft Word" (2010) were used to present the results.

In the descriptive statistics of the studied groups and the control group, frequency tables with absolute numbers and percentages, arithmetic mean, median, standard deviation, minimum and maximum values were used. Graphically, mean measurements are presented with box-plot graphics and categorical data with bar graphics. "Jamovi software 2.2.0" was used to visualize the obtained data.

In the intergroup comparison of the differences in the studied indicators between the individual studied groups (with odontogenic abscesses, with non-odontogenic abscesses and control group), variation analysis "ANOVA" was used. In them, the graphical visualization of the compared numerical values of the investigated markers is presented with "Error Bar Graphics". "Post-Hoc" analysis using Tukey and Games-Howell methods was used to check between which of the studied groups there were statistically significant differences.

For the intragroup comparison of the differences between the studied indicators, a parametric "Independent T-test" was used for symmetrically distributed data and its corresponding non-parametric "Mann-Whitney U-test" for asymmetrically distributed data. Graphically, the differences in mean measurements of the studied markers are presented with "Error Bar Graphs".

ROC curves were used to determine the predictive accuracy of the indicators we investigated in the study (CRP, WBC, Neutr, PCT and DNI). Graphically, they show the sensitivity and specificity of these markers. The predictability of these indicators is determined by their area under the curve (AUC - area under the curve) and 95% confidence interval (95% CI - confidence interval). Using rock curves, cut-off values of the same markers were determined.

Correlation analysis was used to study the dependencies between the studied clinical indicators and to establish the strength of their influence on each other. Pearson's coefficient (r) was used to determine the strength of correlation between these indicators.

All differences between the values at the $p<0.05$ value accepted for biological experiments were considered statistically significant (reliable).

All tables were created on the software program "Microsoft Word" (2010).

7. RESULTS

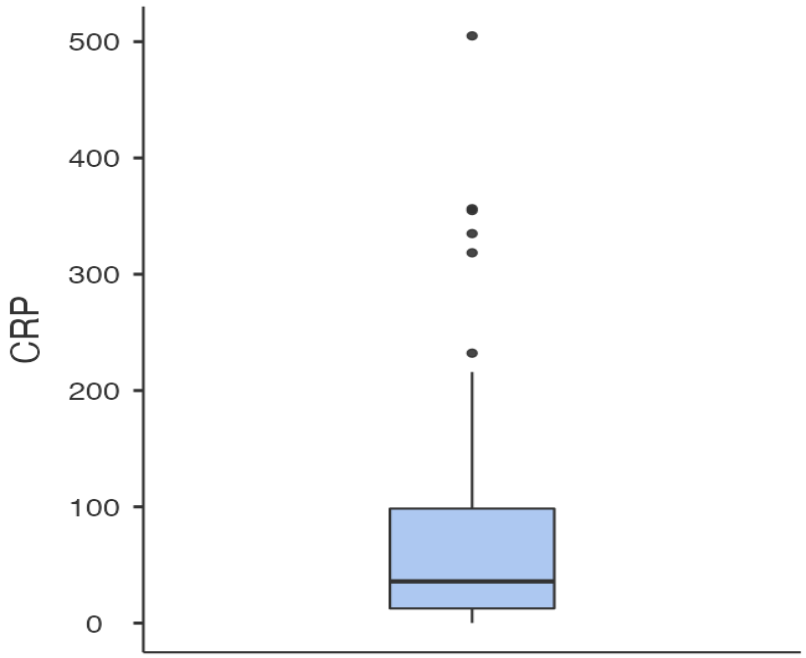
7. 1. Studied group

Table 11 and graphics from 9 to 13 show the average values of the five investigated indicators (PCT, DNI, CRP, WBC and neutrophils) in the studied group of 80 patients with head and neck abscesses of odontogenic and non-odontogenic origin.

Table 11. Average values of PCT, DNI, CRP, WBC and neutrophils in the patients of the studied group

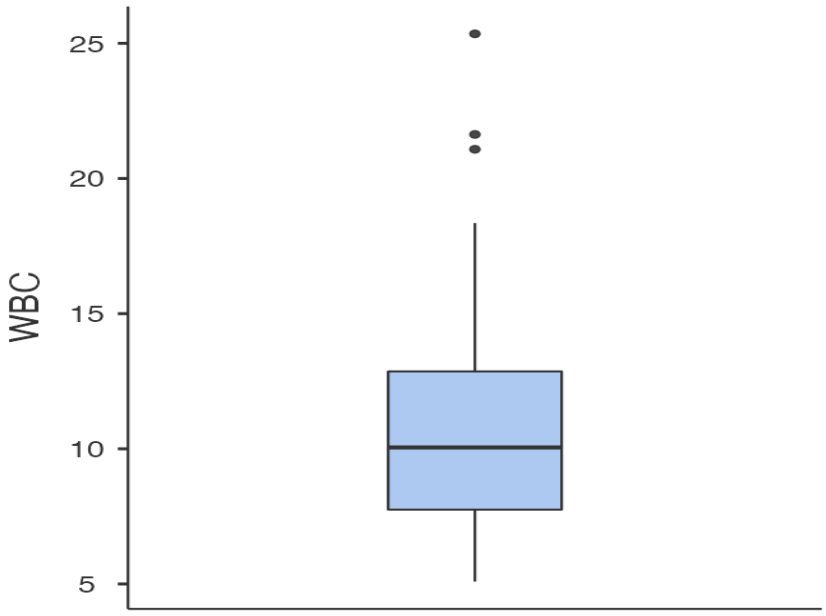
Studied indicator	Number of patients	Mean value	Median	Standard deviation	Minimum value	Maximum value
PCT (ng/ml)	80	0,986	0,38	1,26	0,06	6,75
DNI (%)	80	0,833	1,05	1,64	-4,5	7,4
CRP (mg/l)	80	79,408	35,88	100,5	0,12	504,99
WBC ($x10^3/L$)	80	10,852	10,05	4,01	5,09	25,35
Neutr ($x10^3/L$)	80	7,997	7,7	3,98	3,05	22,28

Graphic 9. Graphic representation of the average measured value of CRP in the patients in the studied group



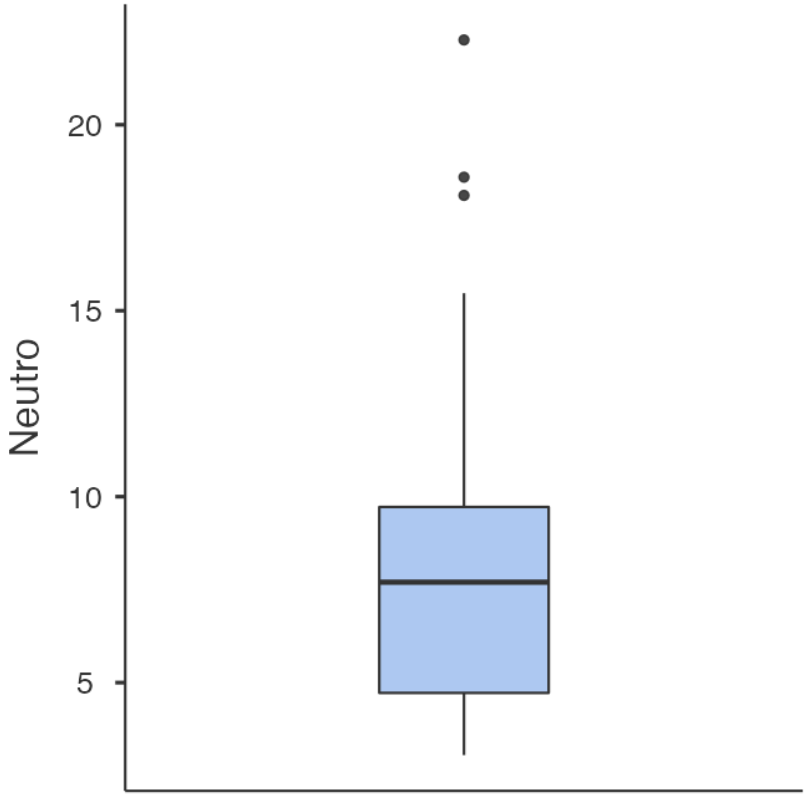
CRP in the studied group has an average value of 79.408±100.5 mg/l. The lowest measured value in the group was 0.12 mg/l and was in a woman with a non-odontogenic abscess in the neck area. The highest was in a patient with a phlegmon of the mouth floor of odontogenic origin and it was 504.99 mg/l.

Graphic 10. Graphic representation of the mean measured WBC value in the patients in the studied group



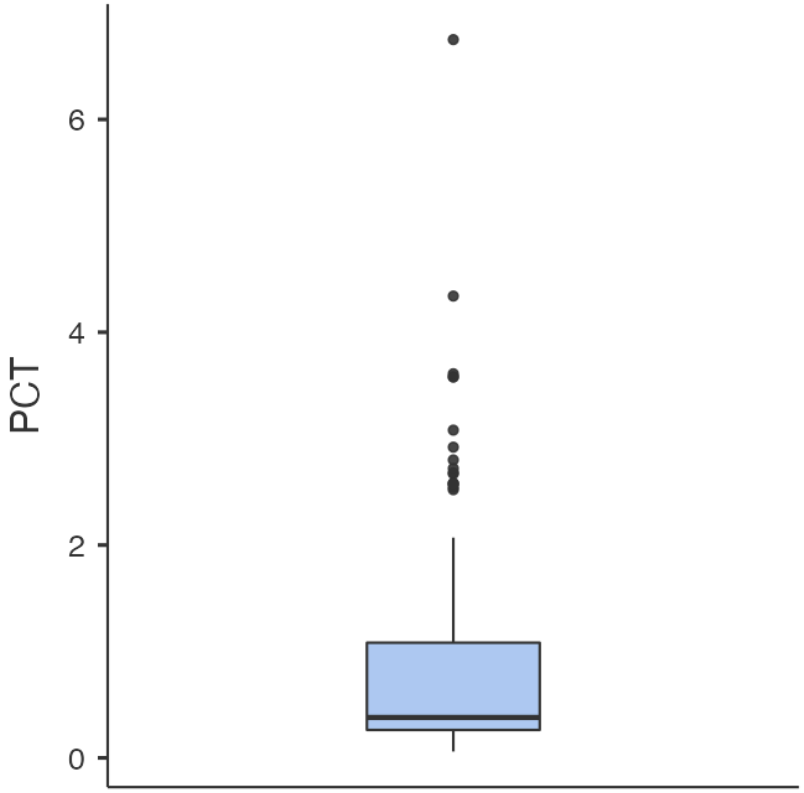
The average value of leukocytes in the peripheral blood of the patients of the studied group was 10.852±4.01x103/L. The lowest measured value was in a woman with a neck abscess of non-odontogenic origin and it was 5.09x103/L, and the highest was measured in a man with a third quadrant submandibular abscess of odontogenic origin and it was 25.35x103/L.

Graphic 11. Graphical representation of the average measured value of neutrophils in the patients in the studied group



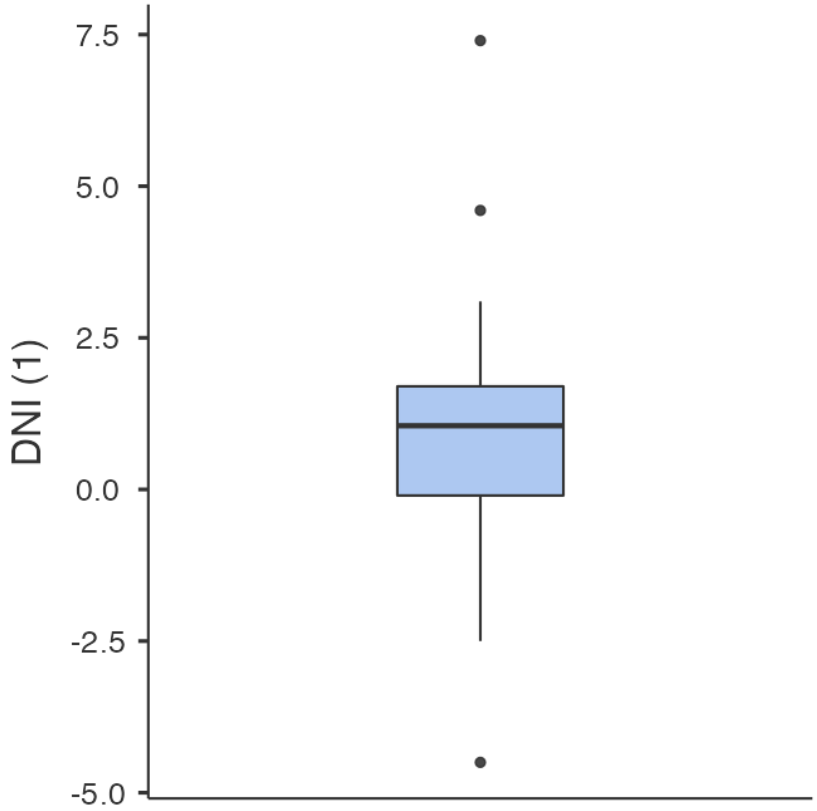
The mean measured value of neutrophils in the patients in the studied group was 7.997±3.98x103/L. The lowest was 3.05x103/L and it was measured in a woman with a third quadrant submucosal abscess of odontogenic origin. The highest was 22.28x103/L and it was measured in the same man with a third quadrant submandibular abscess of odontogenic origin in whom the peripheral blood WBC value was the highest measured.

Graphic 12. Graphical representation of the average measured value of PCT in the patients in the studied group



PCT in the serum of the patients in the studied group had a mean value of 0.986±1.26 ng/ml. The lowest measured value of this indicator was 0.06 ng/ml and it was measured in four patients - in one man with a fourth quadrant submandibular abscess of odontogenic origin, in one woman with fourth quadrant submucosal abscess w of odontogenic origin and in two men with abscesses of non-odontogenic origin in the facial area. The highest was 6.75 ng/ml and it was measured in a man with a non-odontogenic neck abscess.

Graphic 13. Graphical representation of the average calculated value of DNI in the patients in the studied group



The average calculated value of DNI in the study group was 0.833±1.64%. Its lowest value was calculated in a patient with a third quadrant submandibular abscess of odontogenic origin and it was -4.5%. The highest was 7.4% and it was calculated in one of the patients with phlegmons of the mouth floor of odontogenic origin.

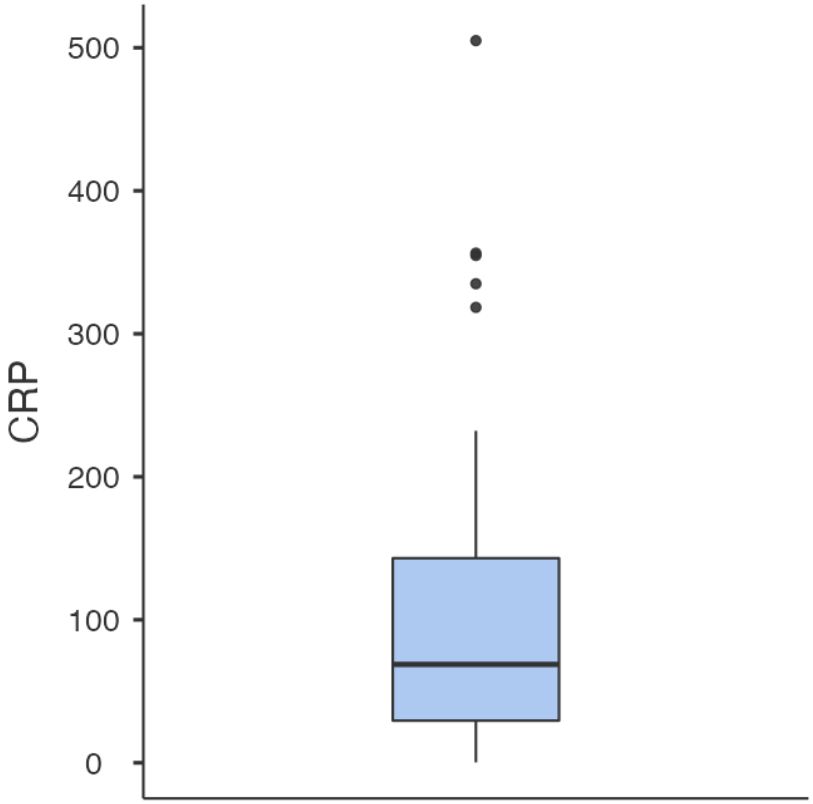
7. 2. Patients with odontogenic abscesses

Table 12 and graphics from 14 to 18 show the average values of the five investigated indicators (PCT, DNI, CRP, WBC and neutrophils) in the studied subgroup of 50 patients with head and neck abscesses of odontogenic origin.

Table 12. Mean values of PCT, DNI, CRP, WBC and neutrophils in the studied subgroup of patients of odontogenic abscesses

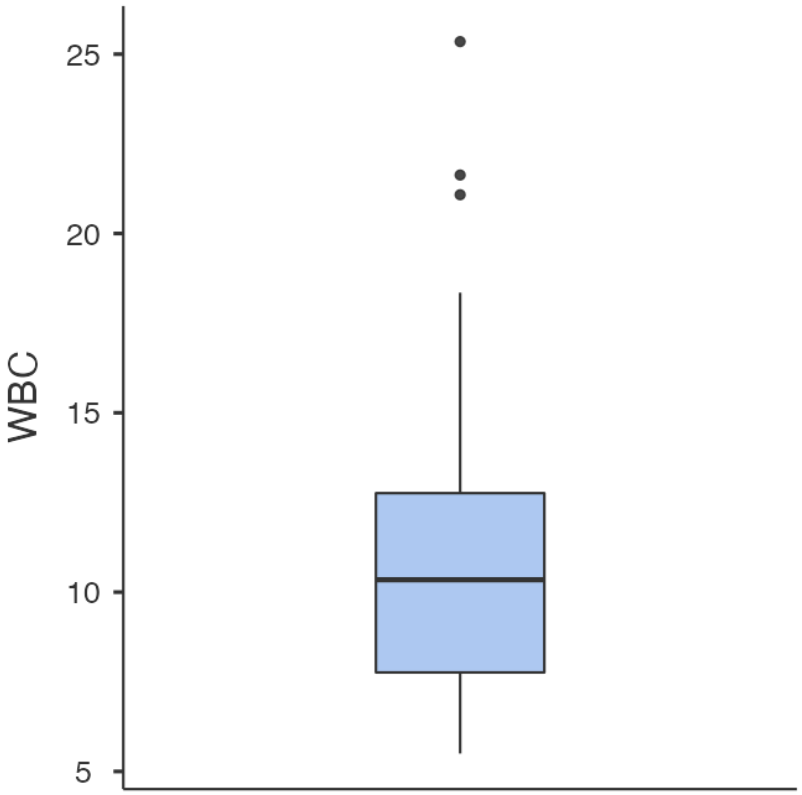
Studied indicator	Number of patients	Mean value	Median	Standard deviation	Minimum value	Maximum value
PCT (ng/ml)	50	0,816	0,375	1,021	0,06	4,34
DNI (%)	50	0,892	0,95	1,871	-4,5	7,4
CRP (mg/l)	50	104,941	68,79	111,753	0,29	504,99
WBC ($x10^3/L$)	50	11,166	10,3	4,43	5,5	25,35
Neutr ($x10^3/L$)	50	8,45	8,27	4,339	3,05	22,28

Graphic 14. Graphical representation of the mean measured CRP value in the patients in the studied subgroup with odontogenic abscesses



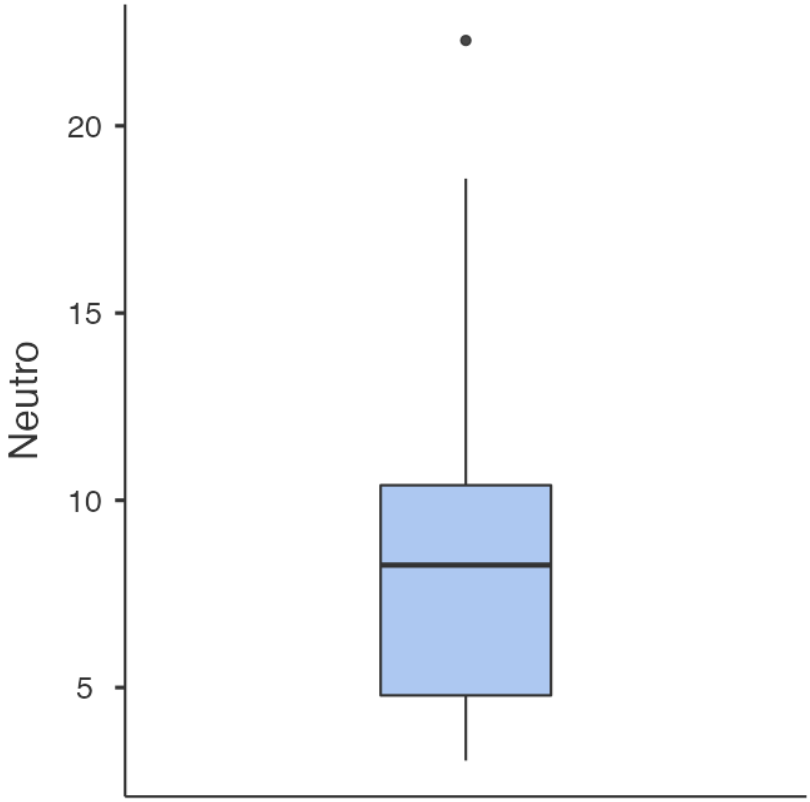
The mean value of CRP in the studied group with odontogenic abscesses was 104.941±111.753 mg/l. The lowest measured value was 0.29 mg/l and it was in a male patient with a fourth quadrant submucosal abscess. Its highest value in this group was in a patient with a phlegmon of the mouth floor of odontogenic origin and it was 504.99 mg/l.

Graphic 15. Graphical representation of the mean measured WBC value in the patients in the studied subgroup with odontogenic abscesses



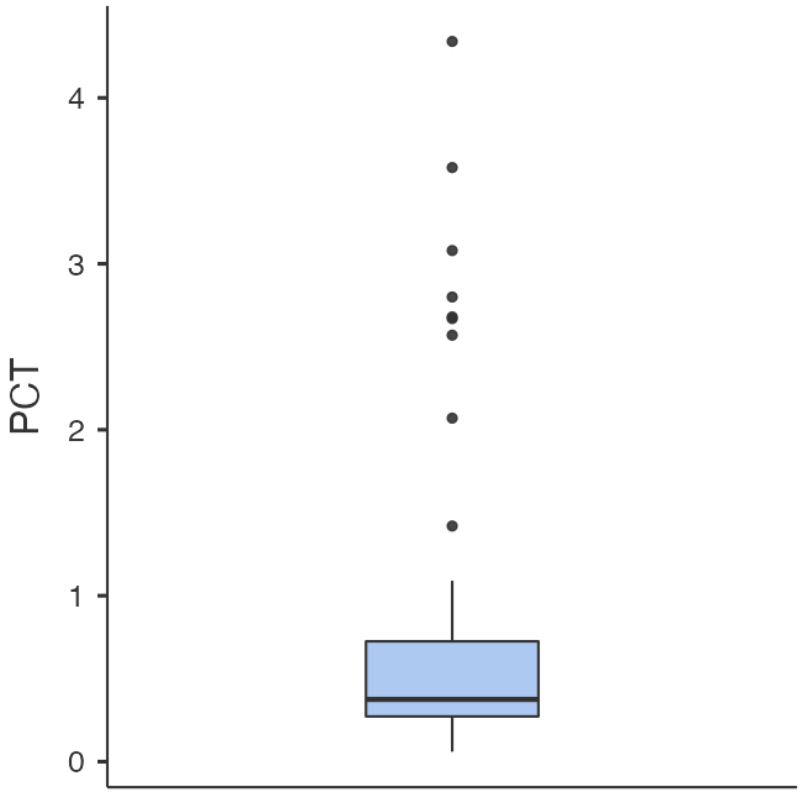
The mean measured WBC value in the odontogenic abscess group was 11.166±4.43x103/L. The lowest measured value in this group was 5.5x103/L and it was in a woman with a third quadrant submucosal abscess. The highest measured value was 25.35x103/L and it was in a man with a submandibular abscess in which the etiological factor was a third quadrant tooth.

Graphic 16. Graphical representation of the average measured value of neutrophils in the studied subgroup of patients with odontogenic abscesses



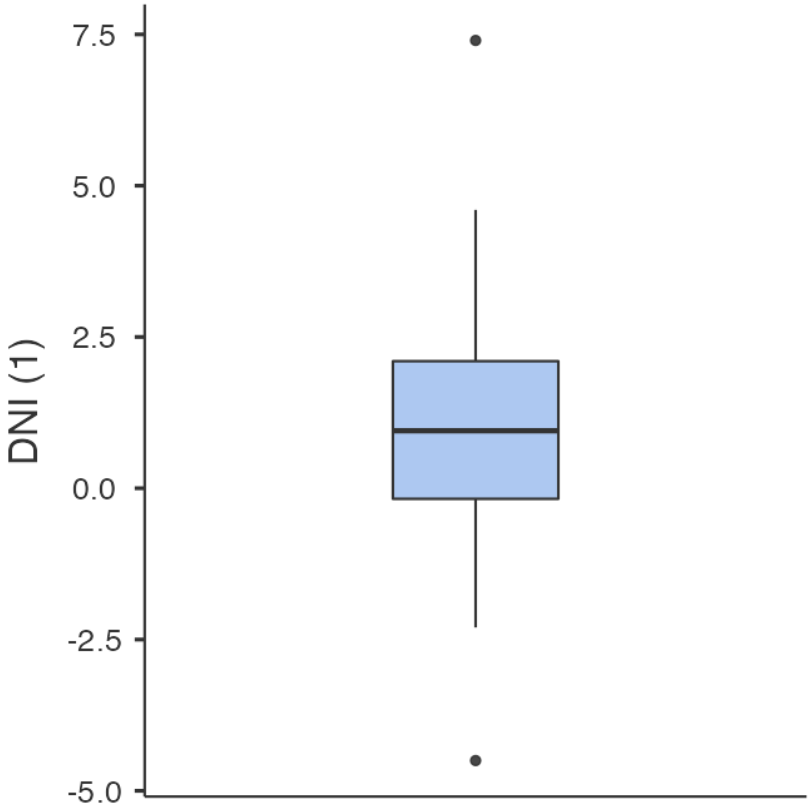
The mean value of neutrophils measured in the group of patients with odontogenic abscesses was 8.45±4.339x103/L. The lowest measured value was 3.05x103/L and it was in a woman with a third quadrant submucosal abscess. The highest measured neutrophil value in this group was 22.28x103/L, measured in a man with a third quadrant submandibular abscess.

Graphic 17. Graphical representation of the mean measured value of PCT in the studied subgroup of patients with odontogenic abscesses



The mean PCT value measured in the group of patients with odontogenic abscesses was 0.816±1.021 ng/ml. The lowest was 0.06 ng/ml and it was measured in four patients—one male with fourth quadrant submandibular abscess of odontogenic origin, one female with fourth quadrant submucosal abscess of odontogenic origin, and two males with non-odontogenic abscesses in the face area. The highest one was 4.34 ng/ml and it was measured in a man with a phlegmon of the mouth floor of odontogenic origin.

Graphic 18. Graphic representation of the average calculated value of DNI in the patients in the studied subgroup with odontogenic abscesses



The mean value of DNI in the patients of odontogenic origin was 0.892±1.871%. The lowest was -4.5% and it was calculated in a male patient with a third dental quadrant submandibular abscess. The highest calculated value was 7.4% and it was in one of the patients with a phlegmon of the mouth floor of odontogenic origin.

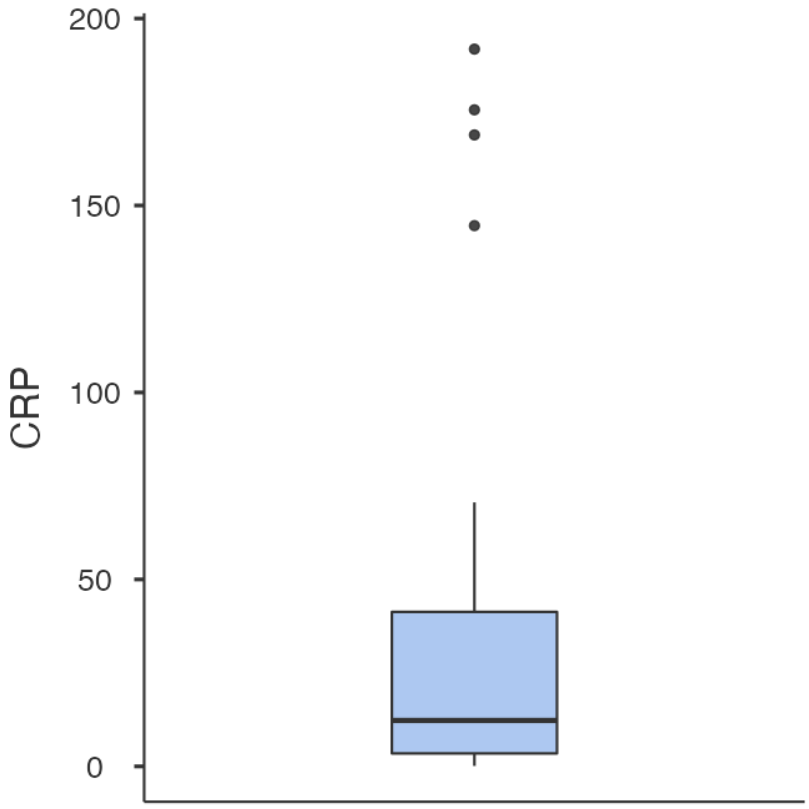
7. 3. Patients with non-odontogenic abscesses

Table 13 and graphics from 19 to 23 show the mean values of the five investigated indicators (PCT, DNI, CRP, WBC and neutrophils) in the studied subgroup of 30 patients with head and neck abscesses of non-odontogenic origin.

Table 13. Mean values of PCT, DNI, CRP, WBC and neutrophils in the studied subgroup patients with non-odontogenic abscesses

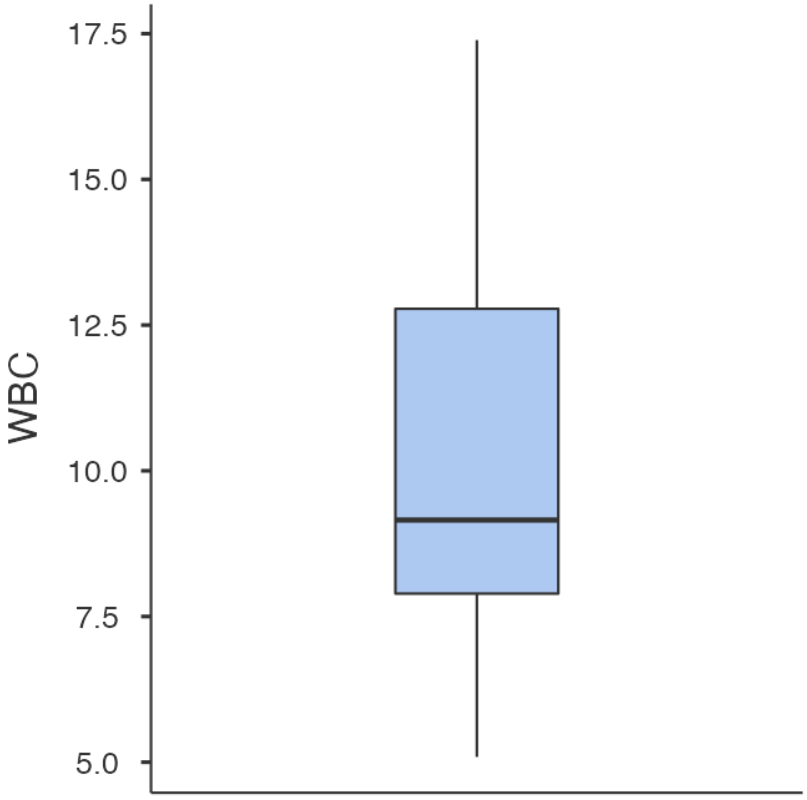
Studied indicator	Number of patients	Mean value	Median	Standard deviation	Minimum value	Maximum value
PCT (ng/ml)	30	1,271	0,405	1,562	0,06	6,75
DNI (%)	30	0,733	1,05	1,2	-2,5	2,9
CRP (mg/l)	30	36,854	12,3	56,288	0,12	191,82
WBC ($x10^3/L$)	30	10,328	9,16	3,192	5,09	17,39
Neutr ($x10^3/L$)	30	7,244	6,5	3,23	3,06	14,64

Graphic 19. Graphical presentation of the mean measured CRP value in the patients in the studied subgroup with non-odontogenic abscesses



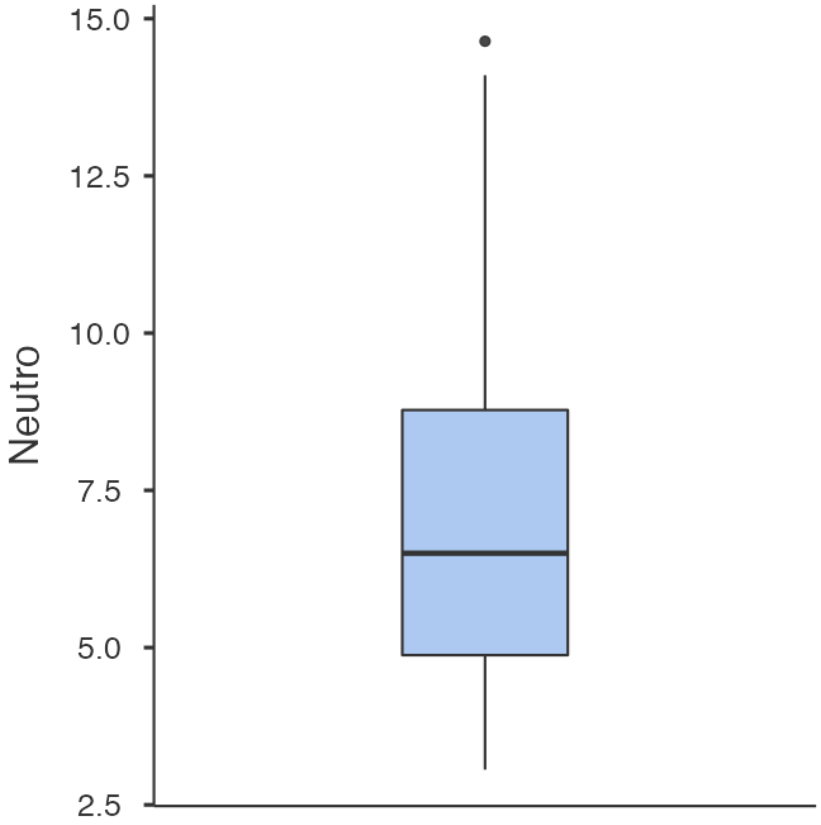
The mean value of CRP in the studied group with non-odontogenic abscesses was 36.854±56.288 mg/l. The lowest was 0.12 mg/l and it was measured in a woman with a neck abscess on her left side. The highest measured value of the indicator in this group was 191.82 mg/l and it was in a male patient with a face phlegmon.

Graphic 20. Graphical representation of the mean measured WBC value in the patients in the studied subgroup with non-odontogenic abscesses



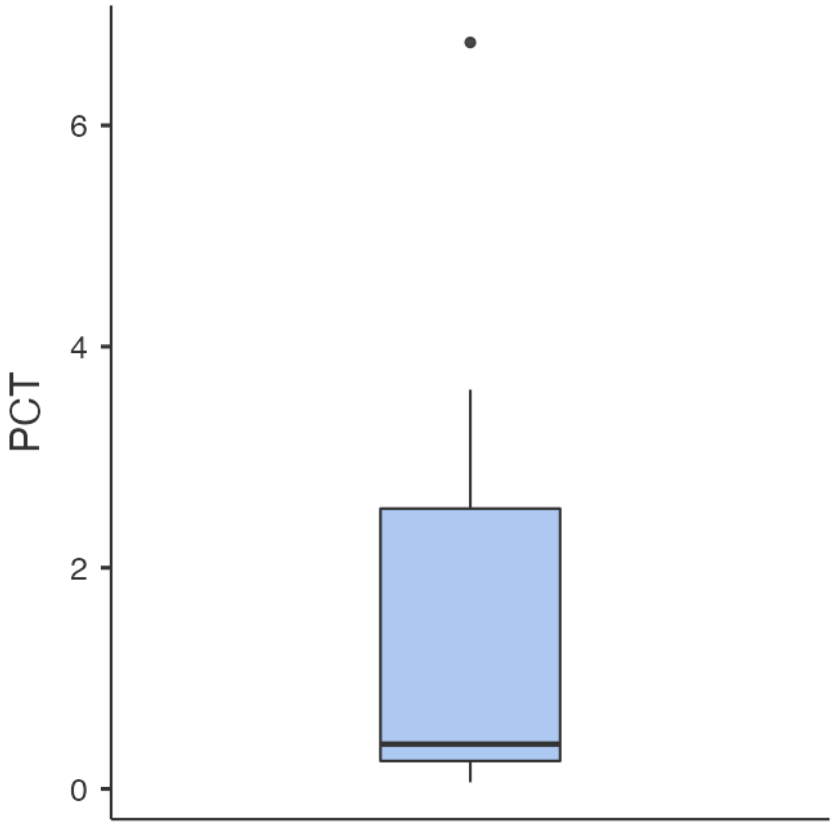
The mean value of WBC in the patients in the studied group with non-odontogenic abscesses was 10.328±3.192x103/L. The lowest value of the indicator in this group was 5.09 x103/L and it was measured in a woman with a neck abscess on her left side. Its highest value was 17.39x103/L, measured in a woman with a neck abscess on her right side.

Graphic 21. Graphical representation of the average measured value of neutrophils in the studied subgroup of patients with non-odontogenic abscesses



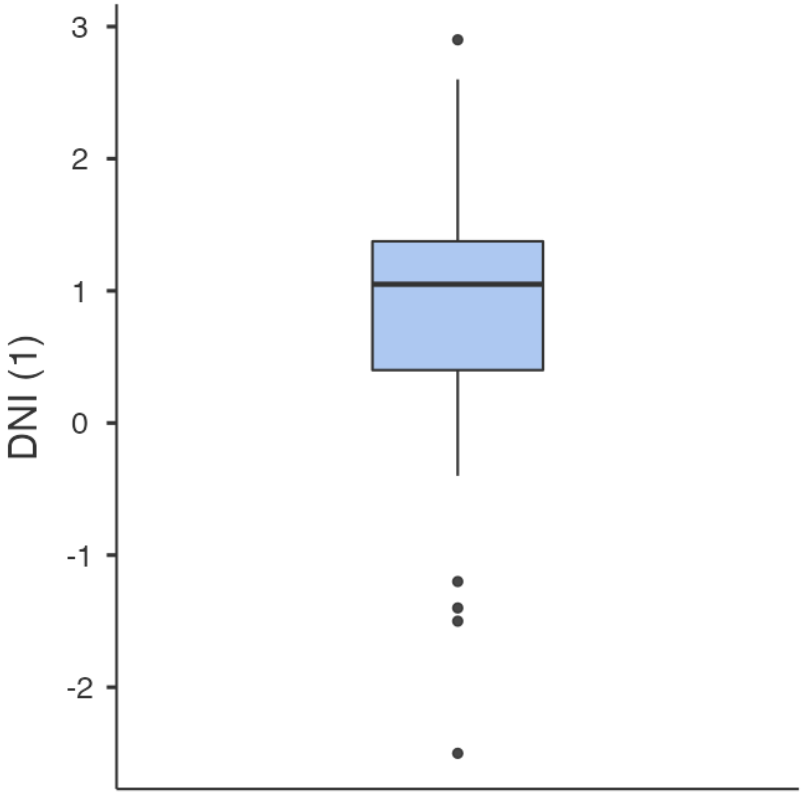
The mean value of neutrophils in the group of patients with abscesses of non-odontogenic origin was 7.244±3.23x103/L. The lowest measured value of the indicator in this group was 3.06x103/L and it was in a man with a facial abscess on his left side. The highest one was 14.64 x103/L and it was in a woman with a neck abscess on her right side.

Graphic 22. Graphical representation of the mean measured value of PCT in the studied subgroup of patients with non-odontogenic abscesses



The mean value of PCT in the studied group of patients with abscesses of non-odontogenic origin was 1,271±1,562 ng/ml. Its lowest value in this group was 0.06 ng/ml and it was measured in two men with abscesses in the facial area, one on the right and the other on the left side. The highest measured PCT value in this group was 6.75 ng/ml and it was in a man with a neck abscess on his right side.

Graphic 23. Graphical presentation of the average calculated value of DNI in the studied subgroup of patients with non-odontogenic abscesses



The average value of DNI in the studied group of patients with non-odontogenic abscesses was 0.733±1.2%. The lowest one was calculated at -2.5% and it was in a woman with an abscess on the face on her left side. The highest value of the indicator in this group is 2.9% and it is in a woman with a neck abscess on her left side.

7. 4. Control group

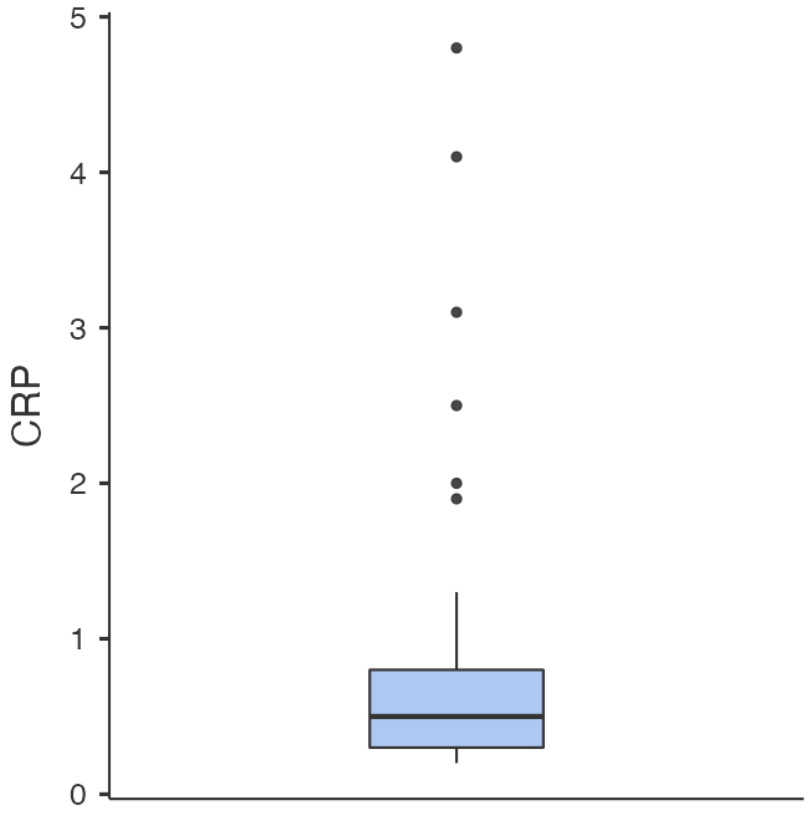
Table 14 and graphics from 24 to 28 show the average values of the five investigated indicators (PCT, DNI, CRP, WBC and neutrophils) in the studied control group of 51 healthy individs.

Table 14. Mean values of PCT, DNI, CRP, WBC and neutrophils in patients from the

control group

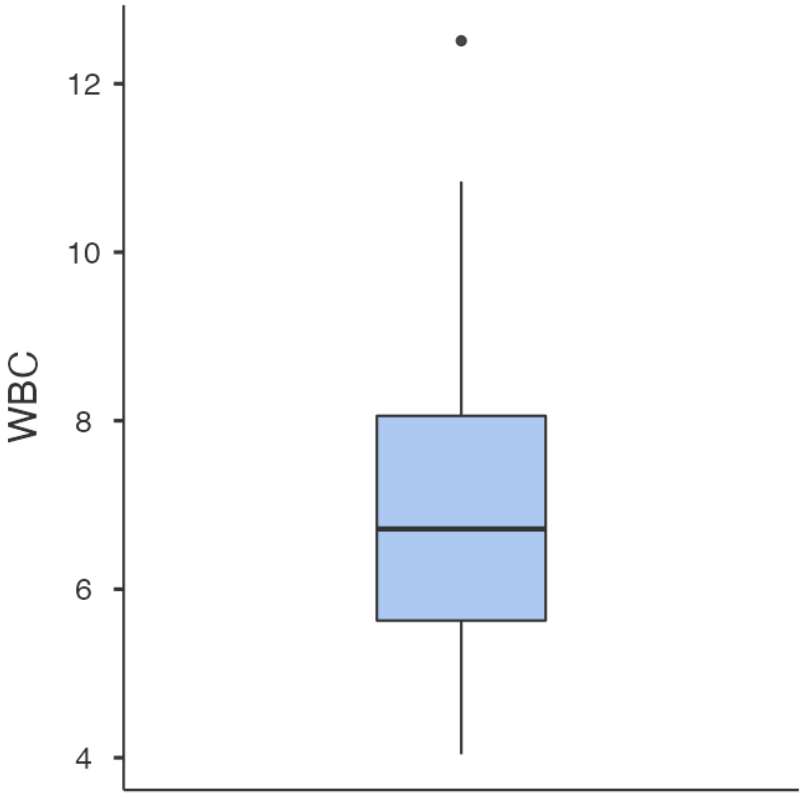
Studied indicator	Number of patients	Mean value	Median	Standard deviation	Minimum value	Maximum value
PCT (ng/ml)	51	0,161	0,125	0,127	0	0,63
DNI (%)	51	-1,145	-0,95	1,514	-7,6	1
CRP (mg/l)	51	0,839	0,5	0,963	0,2	4,8
WBC ($x10^3/L$)	51	7,037	6,715	1,906	4,04	12,51
Neutr ($x10^3/L$)	51	4,019	3,88	1,374	1,72	8,21

Graphic 24. Graphical representation of the average measured value of CRP in the healthy subjects of the control group



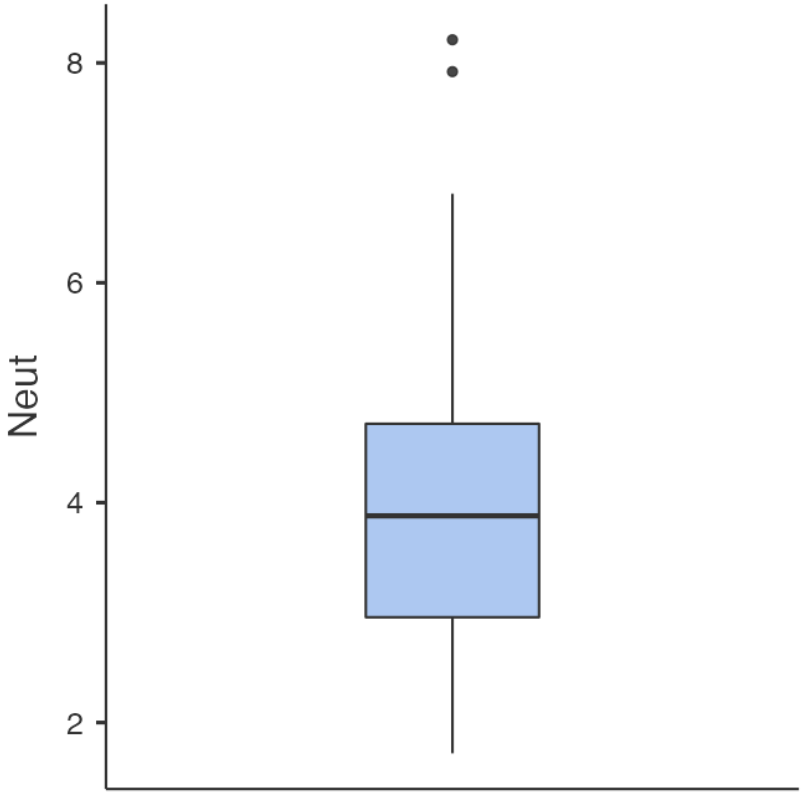
The mean value of CRP in the control group was 0.839±0.963 mg/l. The lowest value of the indicator was 0.2 mg/l and it was measured in nine healthy men and two healthy women. Its highest value was 4.8 mg/l and it was measured in a 65-year-old healthy man.

Graphic 25. Graphical representation of the average measured value of WBC in the healthy subjects of the control group



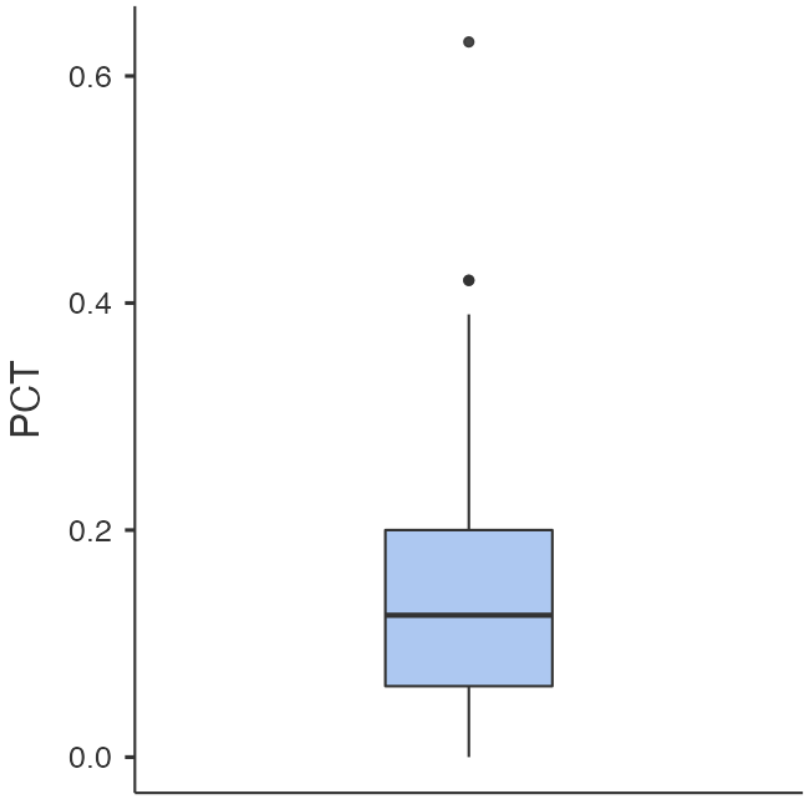
The mean measured WBC value in the control group was 7.037±1.906x103/L. The lowest peripheral blood WBC value of individuals in this group was 4.04x103/L and it was measured in a 67-year-old healthy man. Its highest value was 12.51x103/L and it was measured in a 32-year-old healthy man.

Graphic 26. Graphical representation of the average measured value of neutrophils in the healthy subjects of the control group



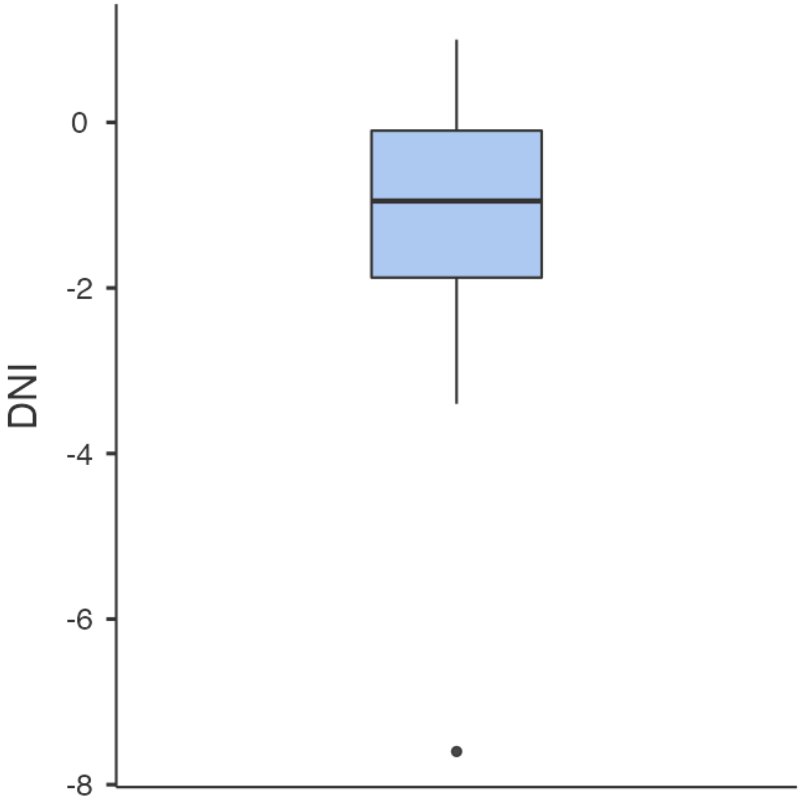
The mean measured value of neutrophils in the control group was 4.019±1.374x103/L. The lowest value of the indicator was measured in a healthy man and it was 1.72x103/L. Its highest value was 8.21x103/L and it was measured in a 32-year-old healthy man.

Graphic 27. Graphical representation of the average measured value of PCT in the healthy subjects of the control group



The mean value of PCT in the study group with healthy controls was 0.161±0.127 ng/ml. Its lowest value was 0 ng/ml and it was measured in a 65-year-old healthy man. The highest PCT value in the control group was 0.63 ng/ml and it was measured in a 65-year-old healthy man.

Graphic 28. Graphical representation of the average calculated value of DNI in the healthy subjects of the control group



The average calculated value of DNI in the control group with healthy people was -1.145±1.514%. Its lowest value was -7.6% and it was measured in a 55-year-old healthy woman. Its highest value was measured in a 41-year-old healthy man and it was 1%.

8. DISCUSSION

8. 1. Comparative analysis of the average values of the studied indicators in the studied group, the subgroups of odontogenic and non-odontogenic abscesses and the control group

8. 1. 1. Comparison and analysis of the obtained data for a studied group and the control group

Analysis of variance "ANOVA" was used to compare the differences in the five studied parameters (PCT, DNI, CRP, WBC and Neutr) in the studied group (80 patients with head and neck abscesses) and the control group (51 healthy subjects). The differences between the values were considered reliable at the accepted value for biological experiments of $p<0.05$. The table below presents the arithmetic mean values for each of the indicators in the respective group.

Table 15 presents and compares the average values of the five investigated indicators (PCT, DNI, CRP, WBC and neutrophils) in the studied group of 80 patients with head and neck abscesses of odontogenic and non-odontogenic origin and in the control group of 51 healthy people.

Table 16 presents the results of the "Independent Samples T-Test" comparing the studied group and the control group with relation to the same measured indicators.

Table 15. Comparison of the study group and the control group by numerical values of PCT, DNI, CRP, WBC and neutrophils

Studied indicator	Studied group	Number of patients	Mean value	Median	Standard deviation	Standard error
PCT (ng/ml)	patients	80	0,986	0,38	1,26	0,06
	controls	51	0,161	0,125	0,127	0,141
DNI (%)	patients	80	0,833	1,05	1,64	0,184
	controls	51	-1,145	-0,95	1,514	0,2141
CRP (mg/l)	patients	80	79,408	35,88	100,5	11,186
	controls	51	0,839	0,5	0,963	0,1361
WBC ($x10^3/L$)	patients	80	10,852	10,05	4,01	0,448
	controls	51	7,037	6,715	1,906	0,2696
Neutr ($x10^3/L$)	patients	80	7,997	7,7	3,98	0,445
	controls	51	4,019	3,88	1,374	0,1943

Table 16. Independent Samples T-Test comparing the studied group and the control group in measured PCT, DNI, CRP, WBC, and neutrophils

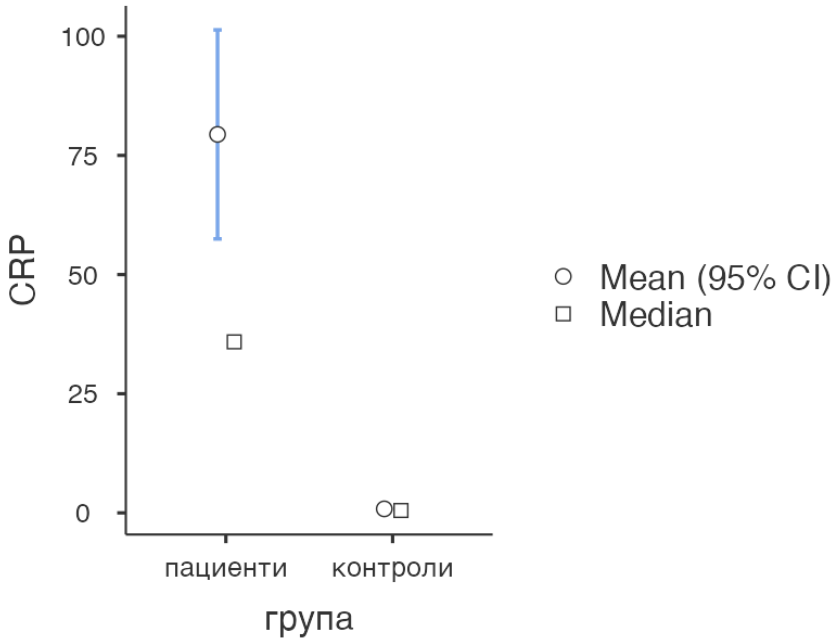
Studied indicator	Statistical method	F	df	p
PCT	Student's t	4,60	128	<0,001
DNI	Student's t	6,87	128	<0,001

CRP	Student's t	5,54	128	<0,001
WBC	Student's t	6,29	128	<0,001
Neutr	Student's t	6,81	128	<0,001

The differences in all five investigated indicators (PCT, DNI, CRP, WBC and Neutr) between the studied group of 80 patients with head and neck abscesses and the control group of 51 healthy people were statistically significant ($p<0.001$).

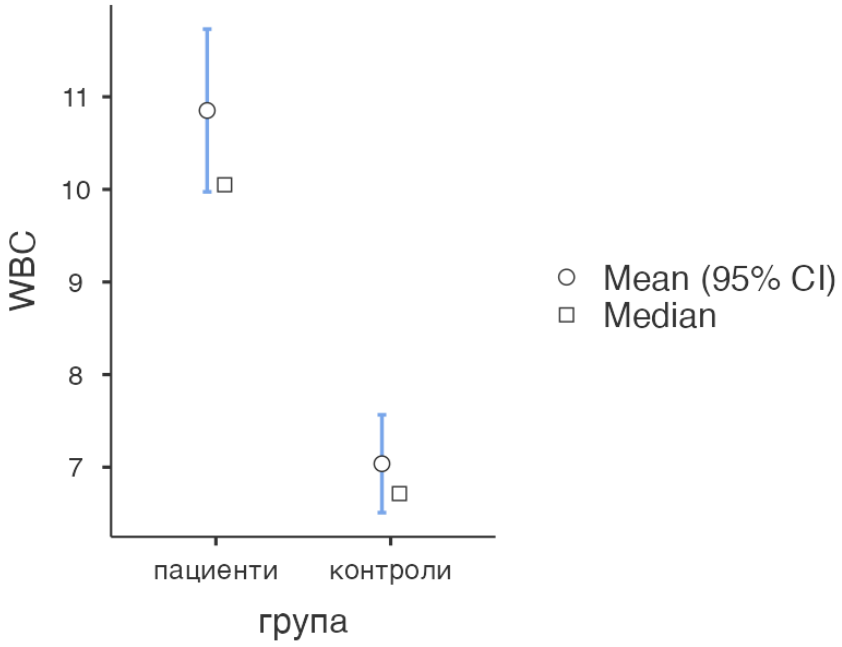
Graphics from 29 to 33 show by means of "Error Bar Graphs" the comparison between the average measured values of the five investigated indicators (CRP, WBC, Neutr, PCT and DNI) between the studied group of 80 patients with head and neck abscesses and the control a group of 51 healthy people.

Graphic 29. Graphical representation of the average measured values of CRP in the patients from the studied group and the healthy individuals from the control group



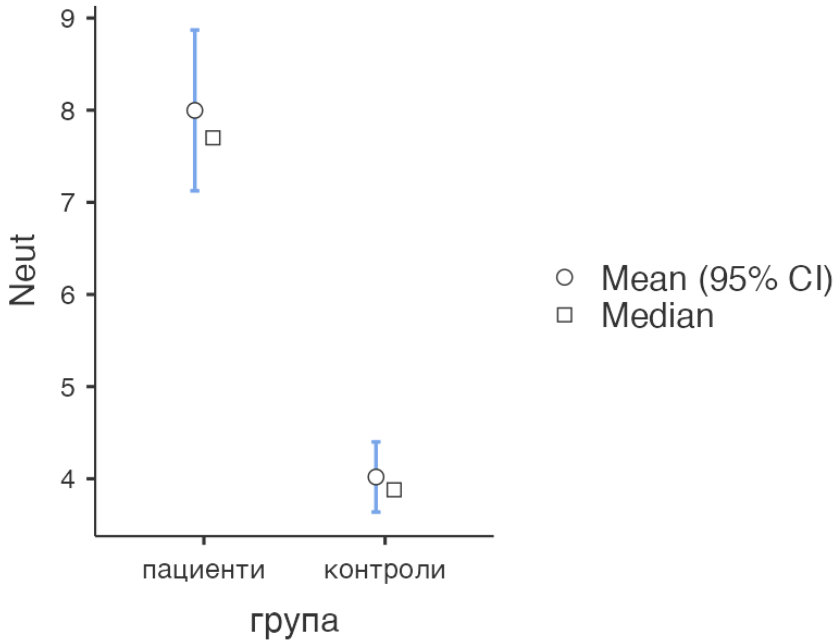
The mean value of CRP in the studied group was 79.408±100.5 mg/l, and in the control group it was 0.839±0.963 mg/l. The value of CRP in the studied group was almost 100 times higher than that in the control group, and the difference was statistically significant ($F=5.54$; $p<0.001$).

Graphic 30. Graphical representation of the average measured values of WBC in the patients of the studied group and the healthy individuals of the control group



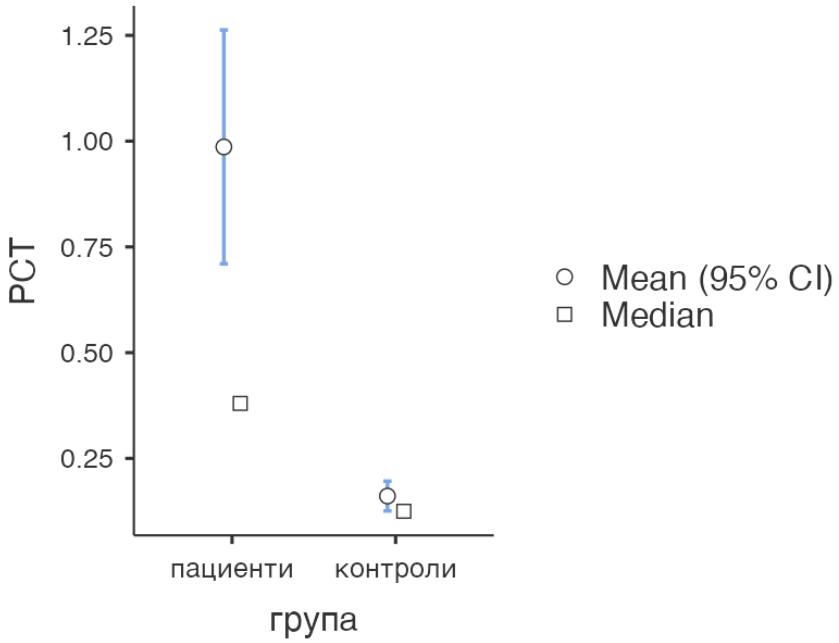
The mean measured value of WBC in the studied group of patients with purulent inflammatory pathology of the head and neck was 10.852±4.01x103/L, and in the control group of healthy people it was 7.037±1.906x103/L. I.e. the mean WBC value of the studied group was 54% higher than that of the control group, and this difference was statistically significant ($F=6.29$; $p<0.001$).

Graphic 31. Graphical representation of the average measured values of neutrophils in patients from the studied group and healthy individuals from the control group



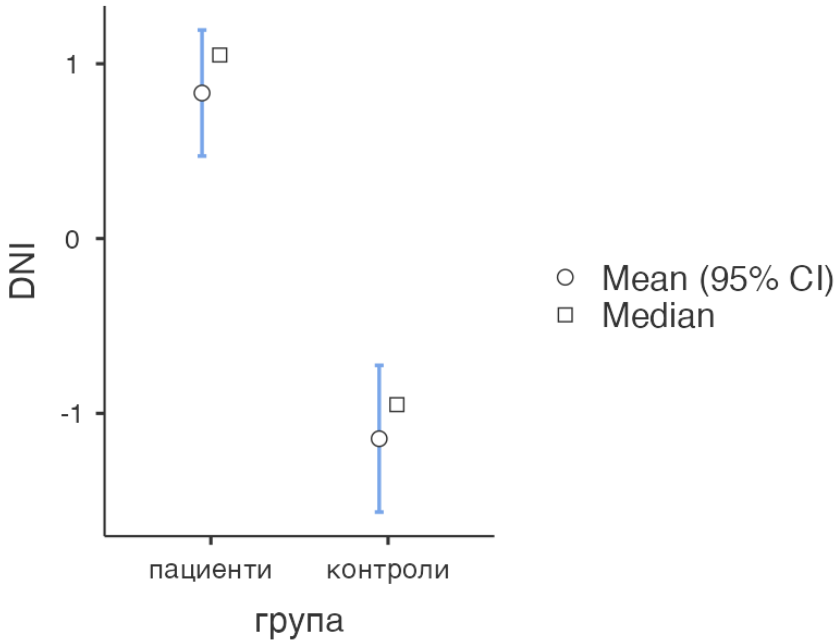
The mean measured value of neutrophils in the studied group of patients was 7.997±3.98x103/L and that of the control group was 4.019±1.374x103/L. I.e. the mean value of neutrophils in the studied group was almost twice higher than it was in the control group, and this difference was statistically significant (F=6.81; p<0.001).

Graphic 32. Graphical representation of the average measured values of PCT in the patients of the studied group and the healthy individuals of the control group



The mean measured value of PCT in the studied group with abscesses was 0.986±1.26 ng/ml, and the mean measured value of the same marker in the control group of healthy people was 0.161±0.127 ng/ml. I.e. the mean PCT value of the studied group was more than six times higher than that of the control group, and this difference was statistically significant (F=4.6; p<0.001).

Graphic 33. Graphical representation of the average calculated values of DNI in patients from the studied group and healthy individuals from the control group



The average calculated value of DNI in the studied group was 0.833±1.64%. The average value of the same in the control group was -1.145±1.514%. I.e. the mean value of DNI in the studied group was almost 2.5 times higher than the same in the control group, and this difference was statistically significant (F=6.87; p<0.001).

As a conclusion, it can be said that all five investigated indicators have significantly higher average values in the studied group of patients with head and neck abscesses compared to the same in the control group of healthy people.

8. 1. 2. Comparison and analysis of the obtained data in the studied subgroups with odontogenic and non-odontogenic abscesses and the control group

Analysis of variance "ANOVA" was used to compare the differences in the five investigated parameters (PCT, DNI, CRP, WBC and Neutr) in the studied subgroups with odontogenic abscesses (50 patients), with non-odontogenic abscesses (30 patients) and the control group (51 healthy individuals). The differences between the values were considered reliable at the accepted value for biological experiments of $p<0.05$.

Table 17 below presents the arithmetic mean values for each of the five studied indicators in the respective groups and subgroups.

Table 18 presents the results of the "Independent Samples T-Test" comparing the studied group and the control group with relation to the same measured indicators.

Table 17. Comparison of the studied subgroups with odontogenic and non-odontogenic abscesses and the control group by numerical values of PCT, DNI, CRP, WBC and neutrophils

Studied indicator	Studied group	Number of patients	Mean value	Median	Standard deviation	Standard error
PCT (ng/ml)	odontogenic	50	0,816	0,375	1,021	0,1443
	non-odontogenic	30	1,271	0,405	1,562	0,2853
	controls	51	0,161	0,125	0,127	0,141
DNI (%)	odontogenic	50	0,892	0,95	1,871	0,2646

	non-odontogenic	30	0,733	1,05	1,2	0,2191
	controls	51	-1,145	-0,95	1,514	0,2141
CRP (mg/l)	odontogenic	50	104,941	68,79	111,753	15,8043
	non-odontogenic	30	36,854	12,3	56,288	10,2768
	controls	51	0,839	0,5	0,963	0,1361
WBC ($x10^3/L$)	odontogenic	50	11,166	10,3	4,43	0,6264
	non-odontogenic	30	10,328	9,16	3,192	0,5828
	controls	51	7,037	6,715	1,906	0,2696
Neutr ($x10^3/L$)	odontogenic	50	8,45	8,27	4,339	0,6136
	non-odontogenic	30	7,244	6,5	3,23	0,5898
	controls	51	4,019	3,88	1,374	0,1943

Table 18. Independent Samples T-Test comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group in terms of measured PCT, DNI, CRP, WBC and neutrophils

Studied indicator	F	df1	df2	p
PCT	17,3	2	49,4	<0,001
DNI	25,3	2	80,6	<0,001
CRP	27,5	2	48,6	<0,001
WBC	26,8	2	63,8	<0,001
Neutr	33,7	2	57,5	<0,001

The differences in all five investigated indicators (PCT, DNI, CRP, WBC and Neutr) between the studied subgroups with odontogenic abscesses (50 patients), with non-odontogenic abscesses (30 patients) and the control group (51 healthy individuals) were statistically significant ($p<0.001$).

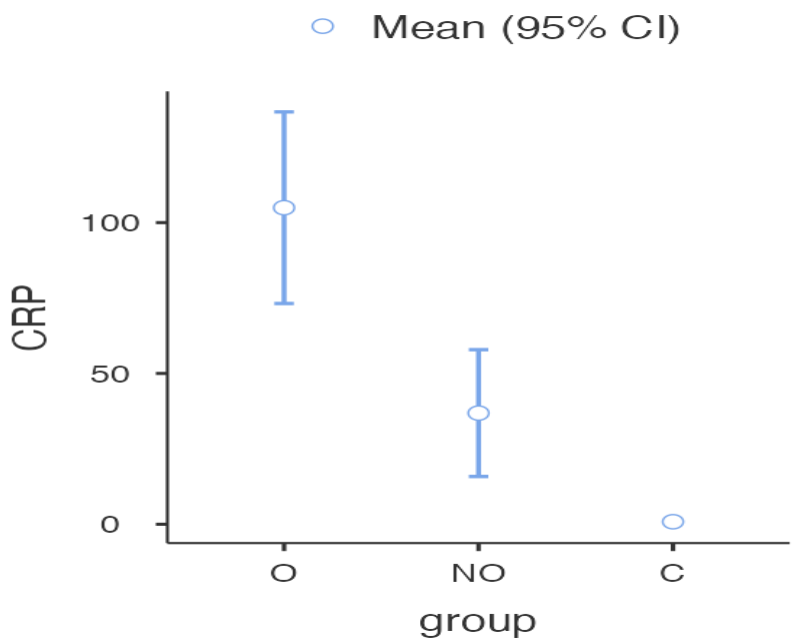
Tables from 19 to 23 present the results of Post-Hoc analysis by the Games-Howell method comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group in terms of the studied indicators (PCT, DNI, CRP, WBC and neutrophils).

Graphics from 34 to 38 present by means of "Error Bar Graphs" the average measured values of PCT, DNI, CRP, WBC and neutrophils in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group.

Table 19. Games-Howell post-hoc analysis comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group with relation to the measured CRP

Games-Howell Post-Hoc Test – CRP				
		odontogenic abscesses	non-odontogenic abscesses	control group
odontogenic abscesses	68,087	—	68,087	104,102
	p-value	—	0,002	<0,001
non-odontogenic abscesses	Mean difference		—	35,999
	p-value		—	0,004
control group	Mean difference			—
	p-value			—

Graphic 34. Graphic representation of the average measured values of CRP in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group



O – studied subgroup with odontogenic abscesses, NO – studied subgroup with non-odontogenic abscesses, C – control group

Regarding the average measured CRP values, significant differences were observed in the indicator in all three groups - with odontogenic abscesses, with non-odontogenic abscesses and the control group. In patients with odontogenic abscesses, the mean measured value was 104.941±111.753 mg/l, in those with non-odontogenic abscesses it was 36.854±56.288 mg/l, and in healthy controls it was 0.839±0.963 mg/l, and this difference was statistically significant ($F=27.5$; $p<0.001$).

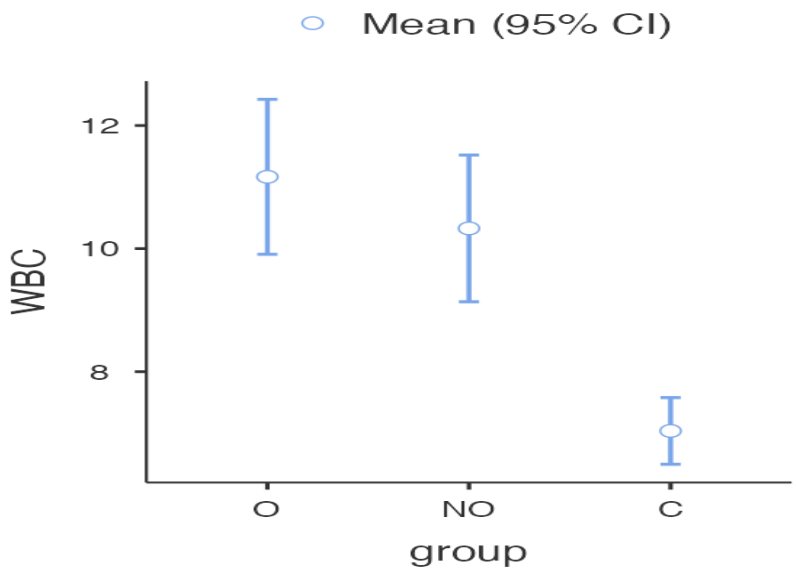
Through the Post-Hoc analysis using the Games-Howell method, we find that the differences between the three compared groups in terms of CRP are statistically significant - between the subgroup with odontogenic abscesses and the control group ($p<0.001$), between the subgroup with non-odontogenic abscesses and the control group ($p=0.004$) and between the subgroup with odontogenic abscesses and the subgroup with non-odontogenic abscesses ($p=0.002$).

I.e. the mean measured value of CRP in the studied subgroup with odontogenic abscesses was almost 109 times higher than that of the control group. The same in the studied subgroup with non-odontogenic abscesses is more than 38 times higher compared to its average numerical value in the control group.

Table 20. Games-Howell Post-Hoc analysis comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group with relation to the measured WBC

Games-Howell Post-Hoc Test – WBC				
		odontogenic abscesses	non-odontogenic abscesses	control group
odontogenic abscesses	Mean difference	—	0,838	4,129
	p-value	—	0,592	<0,001
non-odontogenic abscesses	Mean difference		—	3,291
	p-value		—	<0,001
control group	Mean difference			—
	p-value			—

Graphic 35. Graphical representation of the average measured values of WBC in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group



O – studied subgroup with odontogenic abscesses, NO – studied subgroup with non-odontogenic abscesses, C – control group

Analyzing the average measured values of WBC in the three groups - with odontogenic abscesses, with non-odontogenic abscesses and the control group, significant differences in their numerical values were found. In patients with odontogenic abscesses, the average measured value of the indicator was 11.166±4.43x103/L, in those with non-odontogenic abscesses it was 10.328±3.192x103/L, and in the healthy controls it was 7.037±1.906x103/L, and this difference was statistically significant (F=26.8; p<0.001).

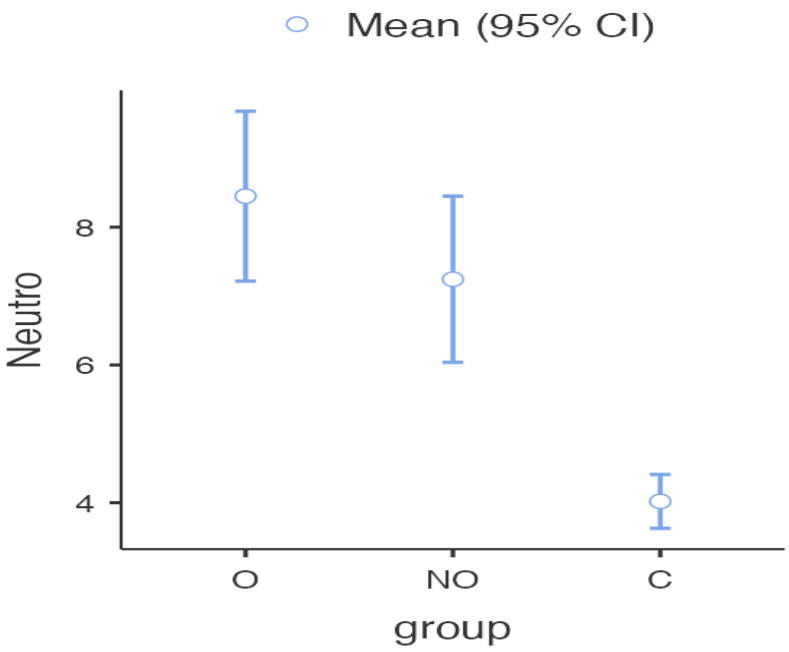
Using Post-Hoc analysis by the Games-Howell method, we found that the differences between the three compared groups in terms of the measured mean WBC numerical values were statistically significant only between the subgroup with odontogenic abscesses and the control group (p<0.001) and between the subgroup with non-odontogenic abscesses and the control group (p<0.001). However, no statistically significant difference was observed between the subgroup with odontogenic abscesses and the subgroup with non-odontogenic abscesses (p=0.592).

The mean measured WBC value in the studied subgroup with odontogenic abscesses was more than 59% higher than that of the control group. The same in the studied subgroup with non-odontogenic abscesses is higher compared to its average numerical value in the control group by more than 46.77%.

Table 21. Post-Hoc analysis by the Games-Howell method comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group in terms of the measured neutrophils

Games-Howell Post-Hoc Test – Neutr				
		odontogenic abscesses	non-odontogenic abscesses	control group
odontogenic abscesses	Mean difference	—	1,206	4,431
	p-value	—	0,338	<0,001
non-odontogenic abscesses	Mean difference		—	3,225
	p-value		—	<0,001
control group	Mean difference			—
	p-value			—

Graphic 36. Graphical representation of the average measured values of neutrophils in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group



O – studied subgroup with odontogenic abscesses, NO – studied subgroup with non-odontogenic abscesses, C – control group

The average measured values of neutrophils in the peripheral blood of the individuals in the three groups - with odontogenic abscesses, with non-odontogenic abscesses and the control group, also show substantial differences in their numerical values, which are statistically significant. In patients with odontogenic abscesses, the mean measured value of the indicator was 8.45±4.339x103/L, in those with non-odontogenic abscesses it was 7.244±3.23x103/L, and in healthy controls it was 4.019±1.374x103/L, and this difference was statistically significant ($F=33.7$; $p<0.001$).

Using the Post-Hoc analysis by the Games-Howell method, we found that the differences between the three compared groups in terms of the measured mean neutrophil counts were statistically significant only between the subgroup with odontogenic abscesses and the control group ($p<0.001$) and between the subgroup with non-odontogenic abscesses and the control group ($p<0.001$). However, no statistically significant difference was observed

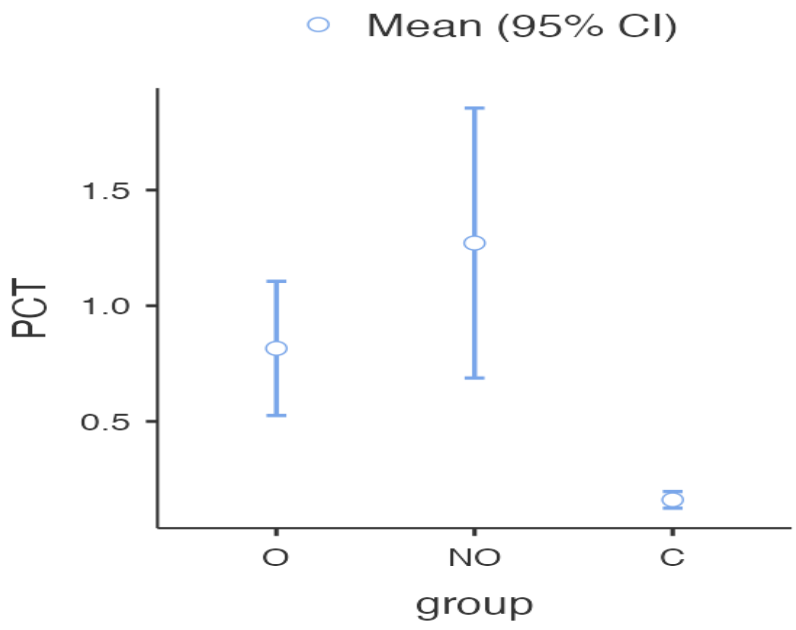
between the two studied subgroups - with odontogenic and non-odontogenic abscesses (p=0.338).

I.e. the average measured value of neutrophils in the study group with odontogenic abscesses was more than 2.1 times higher than that of the control group. The same in the studied group with non-odontogenic abscesses was more than 1.8 times higher than that in the control group.

Table 22. Games-Howell Post-Hoc analysis comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group with relation to the measured PCT

Games-Howell Post-Hoc Test – PCT				
		odontogenic abscesses	non-odontogenic abscesses	control group
odontogenic abscesses	Mean difference	—	-0,455	0,655
	p-value	—	0,337	<0,001
non-odontogenic abscesses	Mean difference		—	1,11
	p-value		—	0,002
control group	Mean difference			—
	p-value			—

Graphic 37. Graphical representation of the average measured values of PCT in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group



O – studied subgroup with odontogenic abscesses, NO – studied subgroup with non-odontogenic abscesses, C – control group

The average measured values of PCT in blood of the individuals in the three groups - with odontogenic abscesses, with non-odontogenic abscesses and the control group, also show significant differences in their numerical values, which are statistically significant. In patients with odontogenic abscesses, the mean measured value of the indicator was 0.816±1.021 ng/ml, in those with non-odontogenic abscesses it was 1.271±1.562 ng/ml, and in healthy controls it was 0.161±0.127 ng/ml, and this difference was statistically significant ($F = 17.3$; $p<0.001$).

Through Post-Hoc analysis using the Games-Howell method, we found that the differences between the three compared groups in terms of the measured mean PCT numerical values were statistically significant only between the subgroup with odontogenic abscesses and the control group ($p<0.001$) and between the subgroup with non-odontogenic abscesses and the control group ($p=0.002$). However, no statistically significant difference was observed between the two studied subgroups - with odontogenic and non-odontogenic abscesses ($p=0.337$).

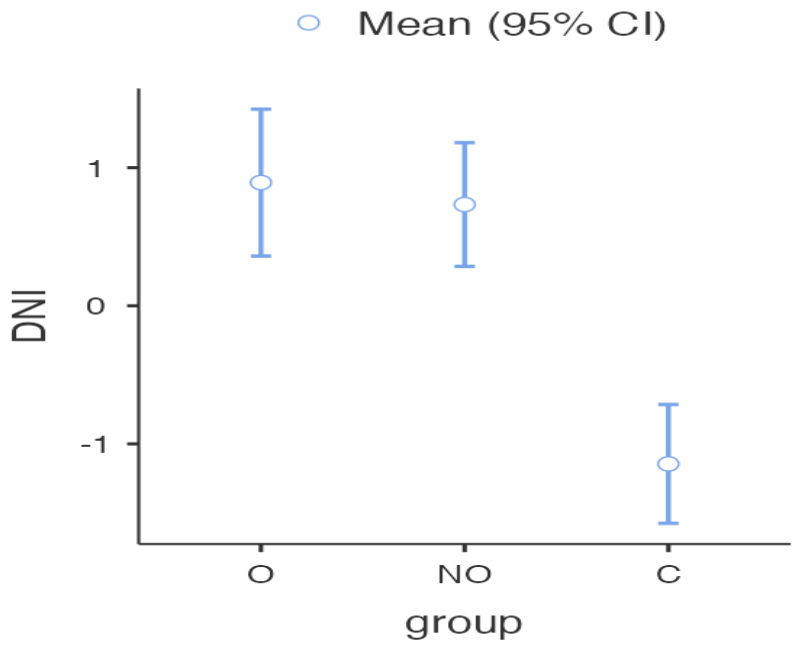
The average measured value of PCT in the studied subgroup with odontogenic abscesses was found to be more than 5 times higher than that of the control group. The same in the studied subgroup with non-odontogenic abscesses is almost 8 times higher than in the

control group.

Table 23. Games-Howell Post-Hoc analysis comparing the studied subgroups with odontogenic and non-odontogenic abscesses and the control group in terms of measured DNI

Games-Howell Post-Hoc Test – DNI				
		odontogenic abscesses	non-odontogenic abscesses	control group
odontogenic abscesses	Mean difference	—	0,159	2,037
	p-value	—	0,889	<0,001
non-odontogenic abscesses	Mean difference		—	1,878
	p-value		—	<0,001
control group	Mean difference			—
	p-value			—

Graphic 38. Graphical representation of the average calculated DNI values in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses and the healthy individuals of the control group



O – studied subgroup with odontogenic abscesses, NO – studied subgroup with non-odontogenic abscesses, C – control group

The average calculated values of DNI in the people in the three groups - with odontogenic abscesses, with non-odontogenic abscesses and the control group, also show significant differences in their numerical values, which are statistically significant. In patients with odontogenic abscesses, the mean measured value of the index was 0.892±1.871%, in those with non-odontogenic abscesses it was 0.733±1.2%, and in healthy controls it was - 1.145±1.514%, and this difference was statistically significant ($F=25, 3$; $p<0.001$).

Through Post-Hoc analysis using the Games-Howell method, we found that the differences between the three compared groups in terms of mean DNI numerical values were statistically significant only between the subgroup with odontogenic abscesses and the control group ($p<0.001$) and between the subgroup with non-odontogenic abscesses and the control group ($p<0.001$). However, no statistically significant difference was observed between the two studied subgroups - with odontogenic and non-odontogenic abscesses ($p=0.889$).

The mean value of DNI in the studied subgroup with odontogenic abscesses was almost 2.3 times higher than that of the control group. The same in the studied subgroup with non-odontogenic abscesses was more than 2.5 times higher than in the control group.

In conclusion, it can be seen that all five investigated indicators have significantly higher average values in the studied subgroups of patients with odontogenic and non-odontogenic head and neck abscesses compared to the same ones in the control group of healthy individuals.

8. 1. 3. Comparison and analysis of the obtained data in the studied subgroups with odontogenic and non-odontogenic abscesses

(intragroup comparison)

Parametric "Independent T -test" (for symmetrically distributed data) and its corresponding non-parametric "Mann-Whitney U" (for asymmetrically distributed data) were used to compare the mean values of CRP, WBC, Neutr, PCT and DNI between the two studied subgroups with odontogenic and non-odontogenic abscesses. The differences between the subgroups were statistically significant at $p \leq 0.05$. The results are presented in tables 24 and 25.

Graphically, the differences in the average measurements are applied separately for each of the studied indicators (graphics 39 to 43).

Table 24. Comparison of the studied subgroups with odontogenic and non-odontogenic abscesses according to numerical values of PCT, DNI, CRP, WBC and neutrophils

Studied indicator	Studied group	Number of patients	Mean value	Median	Standard deviation	Standard error
PCT (ng/ml)	odontogenic	50	0,816	0,375	1,021	0,1443
	non-odontogenic	30	1,271	0,405	1,562	0,2853
DNI (%)	odontogenic	50	0,892	0,95	1,871	0,2646
	non-odontogenic	30	0,733	1,05	1,2	0,2191
CRP (mg/l)	odontogenic	50	104,941	68,79	111,753	15,8043
	non-odontogenic	30	36,854	12,3	56,288	10,2768
WBC ($x10^3/L$)	odontogenic	50	11,166	10,3	4,43	0,6264
	non-odontogenic	30	10,328	9,16	3,192	0,5828
Neutr ($x10^3/L$)	odontogenic	50	8,45	8,27	4,339	0,6136
	non-odontogenic	30	7,244	6,5	3,23	0,5898

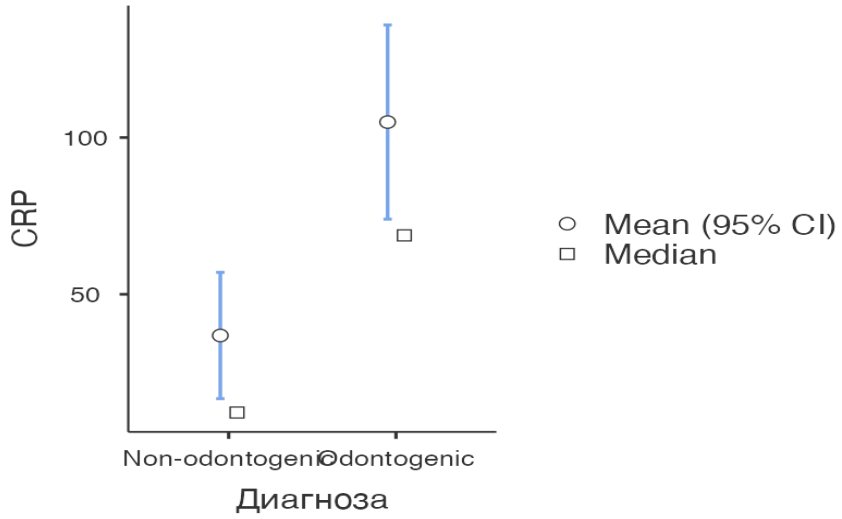
Table 25. Parametric "Independnet T -test" (for symmetric distributed data) and non-parametric "Mann-Whitney U" (for non-symmetrically distributed data) when comparing the studied subgroups with odontogenic and non-odontogenic abscesses in terms of measured PCT, DNI, CRP, WBC and neutrophils

Studied indicator	Statistical method	U	df	p
PCT	Student's t	1,578	78	0,119
DNI	Student's t	-0,415	78	0,679
CRP	Mann-Whitney U	-3,104	78	0,003
WBC	Student's t	-0,904	78	0,369
Neutr	Student's t	-1,317	78	0,192

Regarding the arithmetic averages of the five indicators studied in the two studied subgroups (with odontogenic and non-odontogenic abscesses), significant differences were observed only in CRP, and this difference was statistically significant (p=0.003). For the other four indicators (WBC, Neutr, PCT and DNI), the differences between their mean values are not significant and are not statistically significant (p>0.05).

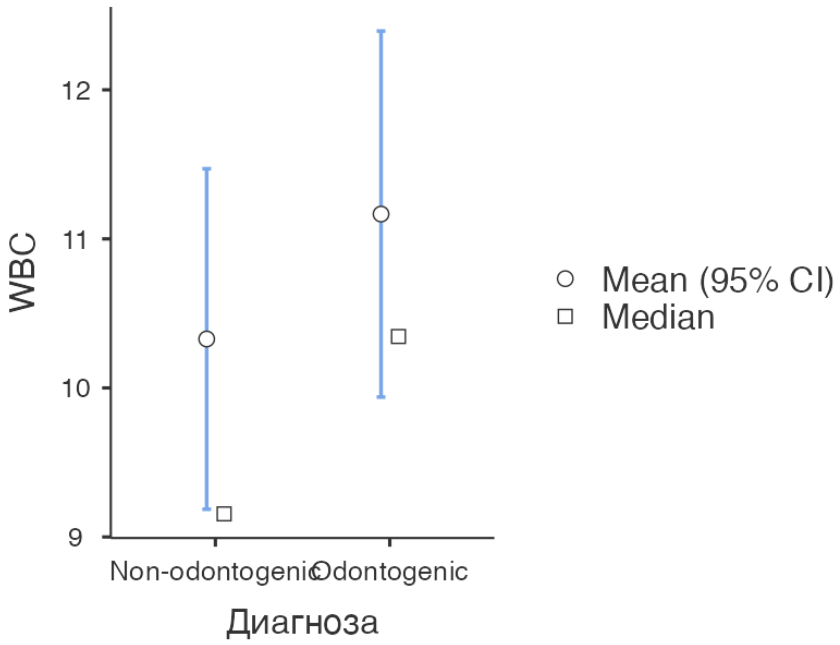
The specific average arithmetic values of the investigated indicators are shown in the graphs below.

Graphic 39. Graphical representation of the average measured values of CRP in the studied subgroups of patients with odontogenic and non-odontogenic abscesses



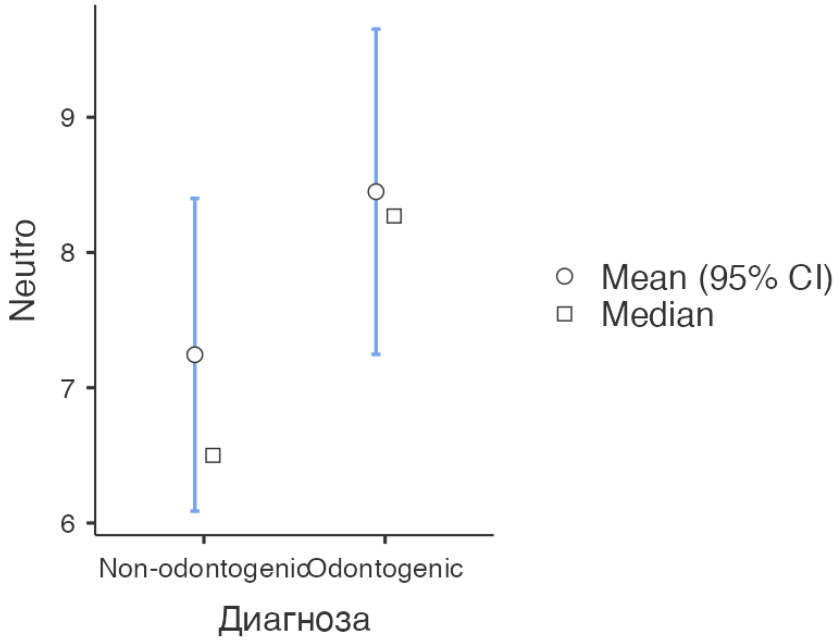
In the subgroup of 50 patients with odontogenic abscesses, the mean measured value of CRP was 104.941±111.753 mg/l. In the one with 30 patients with non-odontogenic abscesses, the same was 36.854±56.288 mg/l. This difference is statistically significant (U=-3.104, p=0.003). I.e. in the studied patients with odontogenic abscesses, the average value of CRP was almost 3 times higher compared to the same in the studied subgroup of patients with non-odontogenic abscesses.

Graphic 40. Graphical representation of the average measured values of WBC in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses



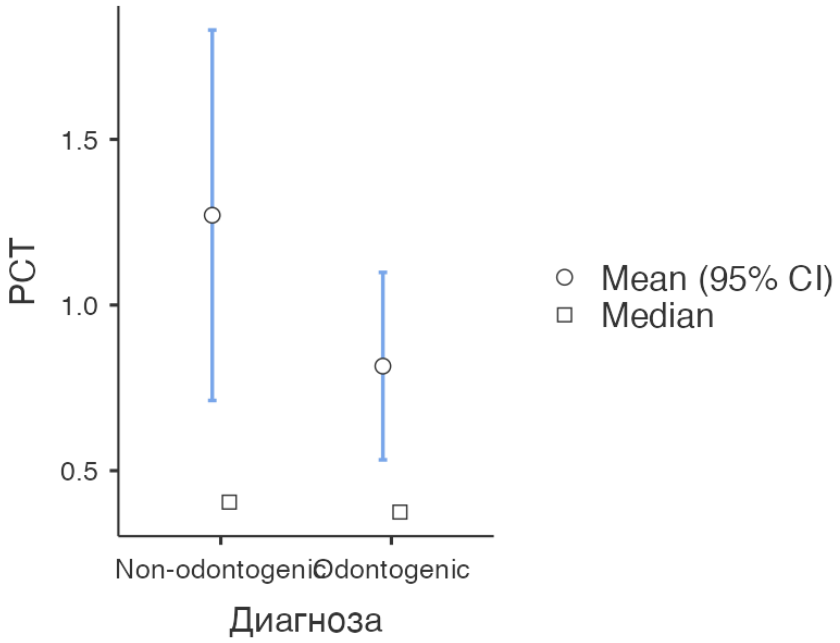
The mean WBC value in patients with odontogenic abscesses was 11.166±4.43x103/L and in those with non-odontogenic abscesses it was 10.328±3.192x103/L. I.e. regarding WBC, there is no significant difference between the mean values of the indicator measured in the two studied subgroups and it is not statistically significant (p=0.369).

Graphic 41. Graphical representation of the average measured values of neutrophils in the studied subgroups of patients with odontogenic and non-odontogenic abscesses



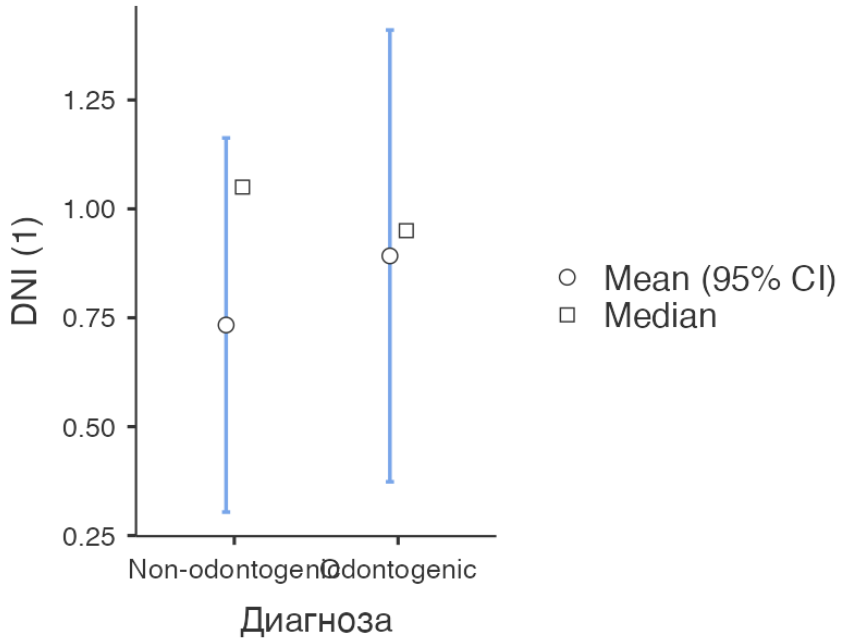
The mean value of neutrophils in patients with odontogenic abscesses was 8.45±4.339x103/L and in those with non-odontogenic abscesses it was 7.244±3.23x103/L. I.e. with regard to neutrophils, there is also no significant difference between the mean values of the indicator measured in the two studied subgroups, and the same is again not statistically significant (p=0.192).

Graphic 42. Graphical representation of the average measured values of PCT in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses



In patients with odontogenic abscesses, the mean PCT value was 0.816±1.021 ng/ml, and in those with non-odontogenic abscesses, it was 1.271±1.562 ng/ml. I.e. regarding PCT, its higher concentration was found in the subgroup with non-odontogenic abscesses, where it was more than 50% higher compared to the same in the patients from the subgroup with odontogenic abscesses. However, this difference was not statistically significant (p=0.119).

Graphic 43. Graphical representation of the average calculated DNI values in the patients of the studied subgroups with odontogenic and non-odontogenic abscesses



In the patients with odontogenic abscesses, the mean DNI value was 0.892±1.871% and in those with non-odontogenic abscesses it was 0.733±1.2%. I.e. with regard to DNI, its slightly higher value was found in the subgroup of patients with odontogenic abscesses compared to the same one in the subgroup of patients with non-odontogenic abscesses. However, this difference was not statistically significant (p=0.679).

The conclusion is that of all the investigated parameters, only CRP can be said that its mean value in the studied subgroup of patients with odontogenic abscesses of the head and neck is higher compared to the same one in the studied subgroup of patients with non-odontogenic abscesses. For WBC, PCT, DNI and neutrophils, it cannot be claimed that their measured mean values were higher in either of the two studied subgroups.

8. 2. Comparative analysis by gender of the studied indicators in the studied groups and subgroups

Table 26 presents and compares the average values of the studied indicators CRP, WBC, neutrophils, PCT and DNI in the studied subgroups with odontogenic and non-odontogenic abscesses and the control group of healthy people in the studied individuals of male and female sex.

Table 26. Comparison by gender of the studied parameters CRP, WBC, neutrophils, PCT and DNI in the studied subgroups with odontogenic and non-odontogenic abscesses and the control group of healthy people

	Odontogenic abscesses				**Non-odontogenic abscesses**				**Control group**			
	Men		**Women**		**Men**		**Women**		**Men**		**Women**	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
CRP (mg/l)	112,73	125,31	95,03	87,5	50,4	63,34	9,77	7,93	0,9	1,19	0,75	0,33
WBC ($x10^3/L$)	11,7	4,96	10,49	3,4	10,47	2,98	10,09	3,43	7,37	1,93	6,54	1,7
Neutr ($x10^3/L$)	8,87	4,86	7,91	3,36	7,55	3,09	6,63	3,25	4,13	1,48	3,86	1,18
PCT (ng/ml)	0,94	1,14	0,71	0,8	1,26	1,74	1,53	1,12	0,18	0,15	0,14	0,08
DNI (%)	1,36	2,09	0,3	1,28	1,11	0,87	-0,01	1,35	-1,07	1,22	-1,26	1,84

Table 27 presents the "p" values when comparing the CRP, WBC, neutrophils, PCT and DNI parameters studied in the studied subgroups with odontogenic and non-odontogenic abscesses and the control group of healthy people by gender.

Table 27. "p" value when comparing by gender the studied indicators CRP, WBC, neutrophils, PCT and DNI in the studied subgroups with odontogenic and non-odontogenic abscesses and the control group of healthy people

p (male/female ratio)	**CRP**	**WBC**	**Neutr**	**PCT**	**DNI**
Odontogenic abscesses	0,29	0,17	0,22	0,23	0,023

Non-odontogenic abscesses	0,03	0,39	0,24	0,34	0,007
Control group	0,29	0,07	0,25	0,13	0,33

When analyzing the group with odontogenic abscesses by gender, it was found that the values of the five studied indicators (CRP, WBC, Neutr, PCT and DNI) in men were higher than those in women. These differences, however, were significant only for DNI (p=0.023). For the other four indicators, the difference is not significant (p>0.05).

Analyzing the subgroup with non-odontogenic abscesses by gender, it is evident that the mean values of CRP, WBC, Neutr and DNI in men were higher than those in women, but this increase was significant only in CRP (p=0.03) and DNI (p=0.007). In the same subgroup, the mean value of PCT was higher in women, but this was not significant (p=0.34).

As a summary of the CRP studies, in both studied subgroups - with odontogenic and non-odontogenic abscesses, higher values were found in men than in women. In the subgroup with odontogenic abscesses, this difference was insignificant (112.73±125.31 mg/l in men vs. 95.03±87.5 mg/l in women) and statistically insignificant (p=0.29). In the subgroup with non-odontogenic abscesses, mean CRP was more than five times higher in men than in women (50.4±63.34 mg/l in men vs. 9.77±7.93 mg/l in women) and this difference was statistically significant (p=0.03). This tendency is also preserved in the control group, where the indicator differs insignificantly as absolute values in both sexes (0.9±1.19 mg/l in men vs. 0.75±0.33 mg/l in women) and the difference did not reach statistical significance (p=0.29).

Summarizing the obtained results for the average values of leukocytes in the subgroups with odontogenic and non-odontogenic abscesses and comparing them with those in the control group, it was concluded that in men in all three groups they were higher than in women (11.7±4 ,96x103/L in men vs. 10.49±3.4x103/L in women in the subgroup with odontogenic abscesses; 10.47±2.98x103/L in men vs. 10.09±3.43x103/L in women in the subgroup with non-odontogenic abscesses; 7.37±1.93x103/L in men vs. 6.54±1.7x103/L in women in the control group). However, these differences were minor and statistically insignificant (p=0.17 in the odontogenic abscess subgroup, p=0.39 in the non-odontogenic abscess subgroup, and p=0.07 in the control group).

Regarding the measured mean values of neutrophils in the subgroups with odontogenic and non-odontogenic abscesses and in the control group, it can be seen that in all

three groups the values in men were higher than in women (8.87±4.86x103/L in men vs. 7.91±3.36x103/L in women in the subgroup with odontogenic abscesses; 7.55±3.09x103/L in men vs. 6.63±3.25x103/L in women in the subgroup with non-odontogenic abscesses; 4.13 ±1.48x103/L in men vs. 3.86±1.18x103/L in women in the control group). However, these differences were also minor and lacked statistical significance (p=0.22 in the odontogenic abscess subgroup, p=0.24 in the non-odontogenic abscess subgroup, and p=0.25 in the control group).

When comparing the PCT studies in both the studied and the control groups, it was found that its average values were higher in men as in the subgroup with odontogenic abscesses (0.94±1.14 ng/ml in men vs. 0.71±0, 8 ng/ml in women) and in the control group (0.18±1.15 ng/ml in men vs. 0.14±0.08 ng/ml in women), and in the subgroup with non-odontogenic abscesses its mean value in women was higher than in men (1.26±1.74 ng/ml in men vs. 1.53±1.12 ng/ml in women). These differences, however, were insignificant and not significantly significant (p=0.23 in the odontogenic abscess group, p=0.34 in the non-odontogenic abscess subgroup, and p=0.13 in the control group).

As a summary of the calculated DNI in both studied subgroups - with odontogenic and non-odontogenic abscesses, and comparing it with the control group, higher values of the indicator were established in men than in women in all three groups. In the subgroup with odontogenic abscesses, this difference was slightly more than 4.5 times in favor of males (1.36±2.09% in males vs. 0.3±1.28% in females) and was statistically significant (p=0.023). In the subgroup with non-odontogenic abscesses, the mean DNI value was 112 times higher than the same in women (1.11±0.87% in men vs -0.01±1.35% in women) and was also statistically significant (p =0.007). In the control group, the difference was insignificant (-1.07±1.22% in men vs. -1.26±1.84% in women) and statistically insignificant (p=0.33).

When comparing CRP in the male study population, it was found that its average measured value in men with odontogenic abscesses was more than twice as high as in men with non-odontogenic abscesses (112.73±125.31 mg/l in men with odontogenic abscesses abscesses versus 50.4±63.34 mg/l in men with non-odontogenic abscesses) and this difference was statistically significant (p=0.026).

When comparing PCT in women from the studied subgroups with odontogenic and non-odontogenic abscesses, it was found that it was more than twice as high in women with non-odontogenic abscesses (0.71±0.8 ng/ml in women with odontogenic abscesses vs. 1 .53±1.12 ng/ml in women with non-odontogenic abscesses) and this difference was significant

(p=0.018). When comparing the DNI in the same two subgroups, its mean values were found to be 301 times higher in women with odontogenic abscesses compared to those with non-odontogenic abscesses (0.3±1.28% in women with odontogenic abscesses vs -0.01± 1.35% in women with non-odontogenic abscesses), but this difference was not statistically significant (p=0.27). When comparing CRP in the same subgroups, it is evident that in women with odontogenic abscesses the mean values of the indicator are almost 10 times higher than those with non-odontogenic abscesses (95.03±87.5 mg/l in women with odontogenic abscesses against 9 .77±7.93 mg/l in women with non-odontogenic abscesses) and the difference was statistically significant (p=0.003).

There are no reports from literature sources that provide information on gender differentiation regarding the values of the five studied markers (CRP, WBC, Neutr, PCT and DNI). It is very likely that the gender differences found in terms of their numerical values in the studied group are due to its inhomogeneity and/or the presence in the two studied subgroups (with odontogenic and non-odontogenic abscesses) of patients with different severity of the clinical picture and different involvement and distribution of the purulent exudate in the anatomical sites of the head and neck – three of the men in the studied subgroup with odontogenic abscesses had phlegmons of the mouth floor and two of the men in the studied subgroup with non-odontogenic abscesses had face phlegmons. The obtained difference is probably also due to the relatively small number of included women in both patient subgroups (with odontogenic and non-odontogenic abscesses) and conclusions about sex-related statistically significant differences between them are speculative.

8. 3. Correlation analysis

In the present study, correlation analysis was used to determine which of the five studied clinical parameters (CRP, WBC, Neutr, PCT, DNI) were dependent and what was the strength of their influence on each other.

The assessment of the strength of the relationship between the variables is based on the results of the Pearson coefficient (r). At $p \leq 0.05$, the degree of association between variables was defined as:

- weak - r between 0.3 and 0.5;

- significant - r between 0.5 and 0.7;

- large – r between 0.7 and 0.9;

- extremely large - r above 0.9.

All significant correlations in this study were positive, i.e. show that with an increase in the numerical value of one studied indicator, the value of the other one increases, and respectively, a decrease in the value of one value leads to a decrease in the numerical value of the other.

All significant correlations are marked with an asterisk.

8. 3. 1. Correlation analysis of the studied group

Table 28 presents the data from the Pearson correlation analysis of the studied group of 80 patients with head and neck abscesses of odontogenic and non-odontogenic origin in relation to the five parameters studied (CRP, WBC, Neutr, PCT and DNI).

Table 28. Correlation analysis by the Pearson method of the studied group with relation to the studied CRP, WBC, Neutr, PCT and DNI

		CRP		**WBC**		**Neutr**		**PCT**		**DNI**	
CRP	**Pearson's (r)**	—									
	p-value	—									
WBC	**Pearson's (r)**	0,549	***	—							

	p-value	<0,001		—							
Neutr	**Pearson's (r)**	0,594	***	0,967	***	—					
	p-value	<0,001		<0,001		—					
PCT	**Pearson's (r)**	0,135		0,100		0,125		—			
	p-value	0,233		0,378		0,271		—			
DNI	**Pearson's (r)**	0,363	***	0,310	**	0,319	**	0,172		—	
	p-value	<0,001		0,005		0,004		0,128		—	
Note: * - p<0,05; **- p<0,01; *- p<0,001**											

The results of the correlation analysis by the Pearson method for the whole studied group of 80 patients with abscesses in the head and neck region (50 with odontogenic and 30 of non-odontogenic origin) showed that there is a positive interaction between the following investigated indicators with the following strength:

- weak - between CRP and DNI (r=0.363; p=0.001), between DNI and WBC (r=0.31; p=0.005) and between DNI and neutrophils (r=0.319; p=0.004);

- significant – between CRP and WBC (r=0.549; p=0.001) and between CRP and neutrophils (r=0.549; p=0.001);

- extremely large - between WBC and neutrophils (r=0.967; p=0.001).

8. 3. 2. Correlation analysis of the studied subgroup with odontogenic abscesses

Table 29 presents the data from the Pearson correlation analysis of the studied

subgroup of 50 patients with head and neck abscesses of odontogenic origin in relation to the five studied parameters (CRP, WBC, Neutr, PCT and DNI).

Table 29. Pearson's correlation analysis of the studied subgroup with odontogenic abscesses in relation to the studied CRP, WBC, Neutr, PCT and DNI

		CRP		**WBC**		**Neutr**		**PCT**		**DNI**	
CRP	**Pearson's (r)**	—									
	p-value	—									
WBC	**Pearson's (r)**	0,565	***	—							
	p-value	<0,001		—							
Neutr	**Pearson's (r)**	0,587	***	0,976	***	—					
	p-value	<0,001		<0,001		—					
PCT	**Pearson's (r)**	0,204		0,021		0,056		—			
	p-value	0,155		0,883		0,698		—			
DNI	**Pearson's (r)**	0,409	**	0,299	*	0,318	*	0,253		—	
	p-value	0,003		0,035		0,025		0,076		—	
Note: * - p<0,05; **- p<0,01; *- p<0,001**											

The analysis of the correlation analysis by the Pearson method for the studied subgroup of 50 patients with odontogenic abscesses shows that there is a positive interaction between the following investigated indicators with the following strength:

- weak - between CRP and DNI (r=0.409; p=0.003) and between DNI and neutrophils (r=0.318; p=0.025);

- significant - between CRP and WBC (r=0.565; p<0.001) and between CRP and neutrophils (r=0.578; p<0.001);

- extremely large - between WBC and neutrophils (r=0.976; p<0.001).

8. 3. 3. Correlation analysis of the studied subgroup with non-odontogenic abscesses

Table 30 presents the data from the Pearson correlation analysis of the studied subgroup of 30 patients with head and neck abscesses of non-odontogenic origin in relation to the five parameters studied (CRP, WBC, Neutr, PCT and DNI).

Table 30. The Pearson correlation analysis of the studied subgroup with non-odontogenic abscesses in relation to the studied CRP, WBC, Neutr, PCT and DNI

		CRP		**WBC**		**Neutr**		**PCT**		**DNI**	
CRP	**Pearson's (r)**	—									
	p-value	—									
WBC	**Pearson's (r)**	0,504	**	—							
	p-value	0,004		—							
Neutr	**Pearson's (r)**	0,608	***	0,941	***	—					
	p-value	<0,001		<0,001		—					
PCT	**Pearson's (r)**	0,309		0,293		0,325		—			
	p-value	0,097		0,116		0,08		—			
DNI	**Pearson's (r)**	0,17		0,338		0,312		0,106		—	
	p-value	0,369		0,068		0,093		0,557		—	
Note: * - p<0,05; **- p<0,01; *- p<0,001**											

Analyzing the correlation analysis according to the Pearson method for the studied subgroup of 30 patients with non-odontogenic abscesses, it is established that there is a positive interaction between the following investigated indicators with the following strength:

- significant - between CRP and WBC (r=0.504; p=0.004) and between CRP and neutrophils (r=0.608; p<0.001);

- extremely large - between WBC and neutrophils (r=0.941; p<0.001).

8. 3. 4. Correlation analysis of the control group

Table 31 presents the data from the Pearson correlation analysis of the studied group of 51 healthy individuals in relation to the five indicators (CRP, WBC, Neutr, PCT and DNI).

Table 31. Correlation analysis by the Pearson method of the control group in relation to the studied CRP, WBC, Neutr, PCT and DNI

		CRP		WBC		Neutr		PCT		DNI	
CRP	**Pearson's (r)**	—									
	p-value	—									
WBC	**Pearson's (r)**	-0,112		—							
	p-value	0,555		—							
Neutr	**Pearson's (r)**	-0,035		0,911	***	—					
	p-value	0,853		<0,001		—					
PCT	**Pearson's (r)**	0,899	***	-0,138		-0,050		—			
	p-value	<0,001		0,466		0,795		—			

DNI	**Pearson's (r)**	0,2		0,072		0,15		0,236		—	
	p-value	0,29		0,707		0,429		0,16		—	
Note: * - p<0,05; **- p<0,01; *- p<0,001**											

According to the correlation analysis by the Pearson method for the control group of 51 healthy individuals, there is a positive interaction between the following investigated indicators with the following strength:

- large - between CRP and PCT (r=0.899; p<0.001) and between CRP and neutrophils (r=0.578; p<0.001);

- extremely large - between WBC and neutrophils (r=0.911; p<0.001).

It can be concluded that in all three – the studied groups of patients with odontogenic and non-odontogenic abscesses of the head and neck, and both studied subgroups of patients with odontogenic and non-odontogenic abscesses, there are significant correlations between CRP and WBC and between CRP and neutrophils and an extremely high correlation between WBCs and neutrophils. The correlations between the other indicators are either insignificant or absent at all.

8. 4. Cut-off diagnostic and reference values of PCT and DNI. Predictability, sensitivity and specificity of the studied indicators in the studied groups

Rock curves (ROC curves - receiver operating characteristic curves) were used to

determine the predictive accuracy of the indicators we investigated in the study (CRP, WBC, Neutr, PCT and DNI).

Graphically, the rock curve through its area under the curve (AUC) and 95% confidence interval (95% CI) shows the predictability of these indicators.

Graphics from 44 to 48 present the ROC curves of the studied indicators (CRP, WBC, Neutr, PCT and DNI) in the studied group of 80 patients with head and neck abscesses of odontogenic and non-odontogenic origin, and tables 32, 34, 36 , 38 and 40 – the characteristics of the corresponding ROC curves.

Tables 33, 35, 37, 39, 41, 42 and 43 present the cut-off values, sensitivity, specificity and predictability of the five investigated parameters (CRP, WBC, Neutr, PCT and DNI) in the studied group of 80 patients with odontogenic and non-odontogenic head and neck abscesses.

Graphic 44. ROC curve of CRP in the studied group of patients with odontogenic and non-odontogenic abscesses

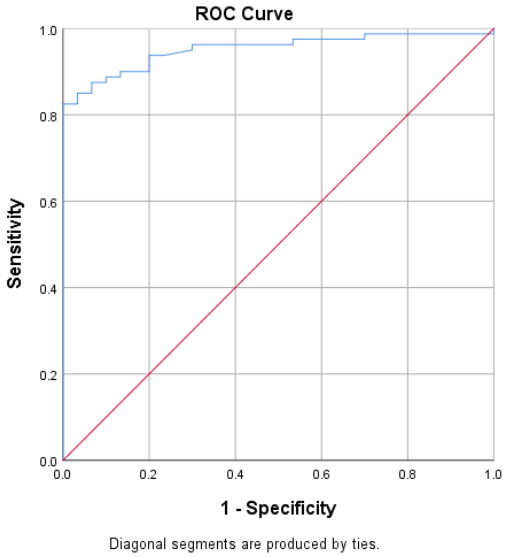


Table 32. Characteristics of the ROC curve of CRP in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator– CRP

AUC			95% CI	
Area	**Standard error**	**p**	**Lower bound**	**Upper bound**
0,925	0,019	0,0001	0,914	0,99

The predictability of CRP in the diagnosis of inflammatory diseases in our studied group of 80 patients with abscesses is 95.2%, and this statement is statistically significant because $p<0.05$ (AUC=0.952; 95% CI: 0.914-0.99 ; p=0.0001).

Table 33. Cut-off value, sensitivity and specificity of CRP in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – CRP			
Cut-off value (mg/l)	**Sensitivity (%)**	**Specificity (%)**	**Standard error (%)**
4,995	81,3	100	0

For the cut-off value of CRP, the value of 4.995 mg/l was determined, where the sensitivity of the indicator is 81.3%. It has a standard error of 0% and a specificity of 100%. I.e. with the available clinical symptoms and/or imaging and a CRP value approximately above 5 mg/l, we can make the diagnosis of odontogenic and non-odontogenic abscess of the head and neck with an absolute accuracy of 100%.

Graphic 45. ROC curve of WBC in the studied group of patients with odontogenic and non-odontogenic abscesses

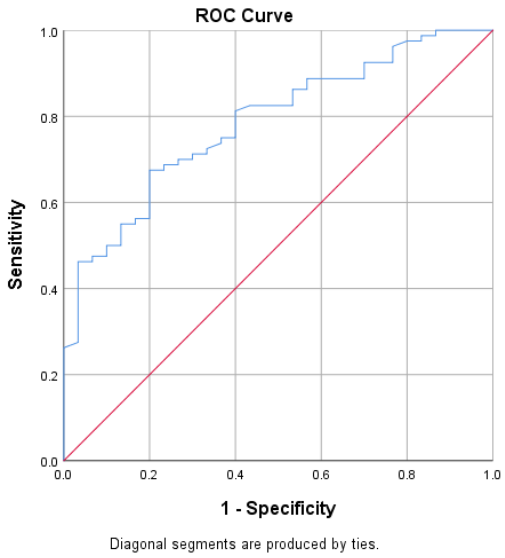


Table 34. Characteristics of the ROC curve of WBC in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – WBC				
AUC			**95% CI**	
Area	**Standard error**	**p**	**Lower bound**	**Upper bound**
0,785	0,045	0,0001	0,697	0,874

The predictability of WBC in the diagnosis of inflammatory diseases in our studied group of 80 patients with abscesses is 78.5%, and this is statistically significant because $p<0.05$ (AUC=0.785; 95% CI: 0.697-0.874; p= 0.0001).

Table 35. Cut-off value, sensitivity and specificity of WBC in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – WBC			
Cut-off value (x10^3/L)	**Sensitivity (%)**	**Specificity (%)**	**Standard error (%)**

8,32	70	73,3	26,7

The cut-off value of WBC obtained in the statistical processing of the data of our study is 8.32x103/L. It corresponds to a sensitivity of 70% and a specificity of 73.3%, and a standard error of 26.7%. I.e. in the presence of clinical symptoms and imaging diagnosis for head and neck abscess and a WBC value above 8.32x103/L, the probability of correctly diagnosing the patient with an abscess of odontogenic or non-odontogenic origin is 73.3%.

Graphic 46. ROC curve of neutrophils in the studied group of patients with odontogenic and non-odontogenic abscesses

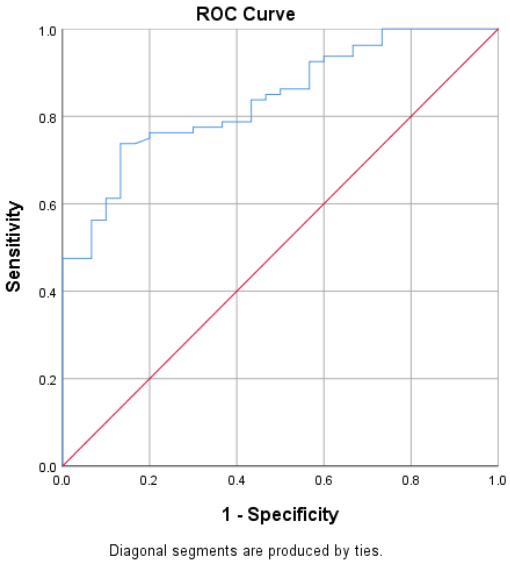


Table 36. Characteristics of the ROC curve of neutrophils in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – Neutr				
AUC			**95% CI**	
Area	**Standard error**	**p**	**Lower bound**	**Upper bound**
0,839	0,038	0,0001	0,764	0,913

The predictability of neutrophils as a marker for the diagnosis of inflammatory diseases in our studied group of 80 patients with odontogenic and non-odontogenic abscesses is 83.9%, and this statement is statistically significant because $p<0.05$ (AUC=0.839; 95% CI: 0.764-0.913; p=0.0001).

Table 37. Cut-off value, sensitivity and specificity of neutrophils in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – Neutr			
Cut-off value *(x10^3/L)*	**Sensitivity (%)**	**Specificity (%)**	**Standard error (%)**
4,69	76,3	80	20

The cut-off value for the studied neutrophils was 4.69x103/L. It corresponds to a sensitivity of 76.3% and a specificity of 80%, and a standard error of 20%. I.e. in the presence of clinical symptoms and imaging diagnostics for a head and neck abscess and a value of neutrophils above 4.69x103/L, the probability of correctly diagnosing the patient with an abscess of odontogenic or non-odontogenic origin is 80%.

Graphic 47. ROC curve of PCT in the studied group of patients with odontogenic and non-odontogenic abscesses

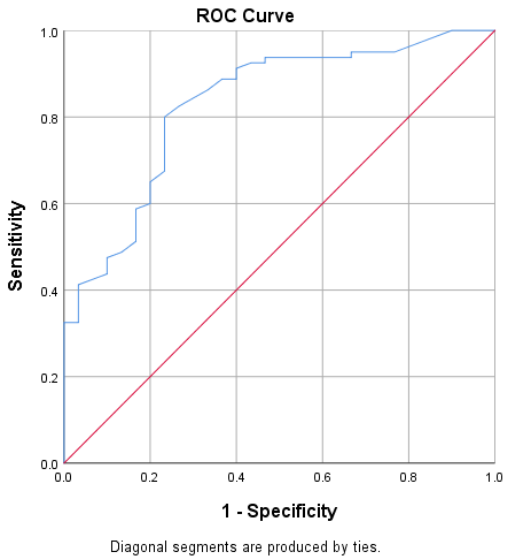


Table 38. Characteristics of the ROC curve of PCT in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – PCT				
AUC			**95% CI**	
Area	**Standard error**	**p**	**Lower bound**	**Upper bound**
0,83	0,043	0,0001	0,745	0,915

The predictability of PCT as a marker for the diagnosis of inflammatory diseases in our studied group of 80 patients with odontogenic and non-odontogenic abscesses is 83%, and this statement is statistically significant because $p<0.05$ (AUC=0.83; 95% CI: 0.745-0.91; p=0.0001).

Table 39. Cut-off value, sensitivity and specificity of PCT in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – PCT			
Cut-off value (ng/ml)	**Sensitivity (%)**	**Specificity (%)**	**Standard error (%)**

0,225	80	76,7	23,3

The PCT cut-off value is its concentration in the patient's blood of 0.225 ng/ml. The sensitivity of this cut-off value was 80%, the specificity was 76.7%, and the standard error that was calculated was 23.2%. I.e. with the available clinical symptoms and/or imaging and a PCT value above 0.225 ng/ml, we can make the diagnosis of odontogenic and non-odontogenic head and neck abscess with an absolute accuracy of 76.7%.

Graphic 48. ROC curve of DNI in the studied group of patients with odontogenic and non-odontogenic abscesses

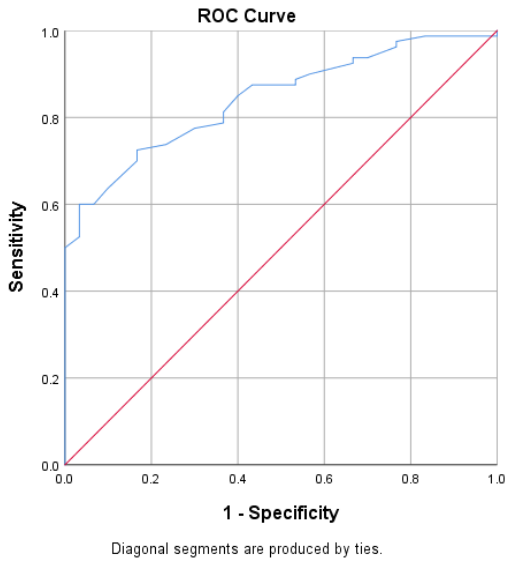


Table 40. Characteristics of the ROC curve of DNI in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – DNI				
AUC			**95% CI**	
Area	**Standard error**	**p**	**Lower bound**	**Upper bound**
0,843	0,037	0,0001	0,771	0,915

The predictability of DNI as a marker for the diagnosis of inflammatory diseases in

our studied group of 80 patients with odontogenic and non-odontogenic abscesses is 84.3%, and this statement is statistically significant because p<0.05 (AUC=0.843; 95% CI: 0.771-0.915; p=0.0001).

Table 41. Cut-off value, sensitivity and specificity of DNI in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator – DNI			
Cut-off value (%)	**Sensitivity (%)**	**Specificity (%)**	**Standard error (%)**
0,15	72,5	83,3	16,7

The cut-off value for DNI is 0.15%. Its corresponding sensitivity was 72.5%, specificity was 83.3%, and standard error was 16.7%. I.e. with the available clinical symptoms and/or imaging and a DNI value above 0.15%, we can make the diagnosis of odontogenic and non-odontogenic head and neck abscess with an absolute accuracy of 83.3%.

Given the high 95% confidence interval (95% CI) in each of the five indicators studied and the fact that in each of them p<0.0001 we can conclude that each of them can be used as a laboratory marker for the diagnosis of odontogenic and non-odontogenic abscesses in the head and neck area.

Table 42. Predictability of the studied parameters CRP, WBC, neutrophils, PCT and DNI in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator	**95% CI**	
	Lower bound	**Upper bound**
CRP	0,914	0,99
WBC	0,697	0,874
Neutr	0,764	0,913
PCT	0,745	0,915
DNI	0,771	0,915

Table 43. Cut-off value, predictability, sensitivity and specificity of the studied indicators CRP, WBC, neutrophils, PCT and DNI in the studied group of patients with odontogenic and non-odontogenic abscesses

Studied indicator	Cut-off value	Predictability (%)	Sensitivity (%)	Specificity (%)
CRP	5 mg/l	92,5	81,3	100
WBC	$8{,}32x10^3/L$	78,5	70	73,3
Neutr	$4{,}69x10^3/L$	83,9	76,3	80
PCT	0,225 ng/ml	83	80	76,7
DNI	0,15%	84,3	72,5	83,3

In conclusion, it can be said that from all studied indicators predictability, sensitivity and specificity were highest for CRP, and lowest for WBC.

The predictability of all investigated indicators is high, ranging from 78.5% to 92.5%. The same in PCT and DNI is almost equal to that of neutrophils and higher than that of WBC.

The sensitivity of each of the five investigated indicators is relatively high, ranging from 70% to 81.3%. The same for PCT and DNI is higher than that of WBC and neutrophils and close to that of CRP.

The specificity of each of the five investigated indicators is high and varies between 73.3% and 100%. The same for PCT and DNI is higher than that of WBC and close to that of neutrophils.

9. CONCLUSIONS

1. The average measured values of the five indicators investigated in the study (CRP, WBC, neutrophils, PCT and DNI) in both studied subgroups of patients with odontogenic and non-odontogenic abscesses were significantly higher than the same in the control group of healthy people;

2. There is no substantial and significant gender differentiation in terms of the indicators investigated in the study (CRP, WBC, neutrophils, PCT and DNI);

3. There were positive correlations between CRP and WBC and between CRP and neutrophils and a strong positive correlation between WBC and neutrophils in the study group of patients with odontogenic and non-odontogenic head and neck abscesses and in both study subgroups of patients with odontogenic and non-odontogenic abscesses. There is no positive correlation between PCT and DNI;

4. For the cut-off values of the indicators investigated in the study, the following numerical measurements were adopted: CRP – 5 mg/l, WBC – 8.32x103/L, neutrophils – 4.69x103/L, PCT – 0.225 ng/ml and DNI – 0.15%;

5. The predictability, sensitivity, and specificity of all parameters tested (CRP, WBC, neutrophils, PCT, and DNI) were highest for CRP and lowest for WBC. The same for PCT and DNI is higher than that for WBC, close to or higher than that for neutrophils, and lower than that for CRP.

10. CONTRIBUTIONS

1. For the first time in Bulgaria, PCT and DNI are used as markers in the management of odontogenic and non-odontogenic head and neck abscesses;

2. For the first time in Bulgaria, a correlation between PCT, DNI, CRP, WBC and neutrophils as markers of inflammation in odontogenic and non-odontogenic head and neck abscesses was made;

3. Determination and follow-up of PCT and DNI in routine practice in patients suspected of odontogenic and non-odontogenic head and neck abscesses may lead to earlier diagnosis and more precise treatment of these diseases;

4. The introduction of DNI as a diagnostic marker of odontogenic and non-odontogenic head and neck abscesses has positive economic dimensions;

5. PCT and DNI cut-off values for the diagnosis of odontogenic and non-odontogenic head and neck abscesses were derived.

11. SCIENTIFIC PUBLICATIONS AND PARTICIPATION IN SCIENTIFIC FORUMS RELATED TO THE DISSERTATION WORK

11. 1. Scientific publications

1) Y. Yankov, Y. Bocheva. The Value of Delta Neutrophil Index in The Odontogenic and Non-odontogenic Abscesses' Surgery of Head and Neck. Varna Medical Forum. 2022;

2) Y. Yankov, Y. Bocheva. Procalcitonin and C-reactive Protein in The Inflammatory Surgery of Head and Neck - Diagnostic Significance and Correlations. Varna Medical Forum. 2022.

11. 2. Participation in scientific forums

1) Y. Yankov, Y. Bocheva, N. Kolev. Evaluation of Both Procalcitonin and Delta Neutrophil Index in Hospitalized Patients with Odontogenic and Non-odontogenic Abscesses. Clin Chem Lab Med 2021; 59. Special Suppl: pp S94 – S998. Nov/Dec 2021;

2) Y. Yankov, Y. Bocheva. Correlation between the serum levels of procalcitonin and CRP in patients with odontogenic and non-odontogenic abscesses in maxillofacial surgery. Clinica Chimica Acta (530): S212-S213.

12. ACKNOWLEDGMENTS

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