MEDICAL UNIVERSITY
"PROF. DR. PARASKEV STOYANOV" – VARNA
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DEPARTMENT OF PERIODONTOLOGY AND DENTAL IMPLANTOLOGY

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CORONARY ARTERY PATHOLOGY IN PATIENTS WITH PERI-IMPLANTITIS
AUTHOR'S ABSTRACT

of a dissertation
for awarding the educational and scientific degree "Doctor"
specialty: Therapeutic Dentistry

Scientific Supervisor: Prof. Dr. Stefan Peev, D.Sc.
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The dissertation consists of 151 pages and is illustrated with 60 tables, 10 figures and 7 papper appendices.
The bibliography includes 179 references, of which 1 is in Cyrillic and 178 are in Latin script.
The number and numbering of the tables and figures in the abstract do not correspond to those in the dissertation.
The public defense of the dissertation will take place on **October 10, 2025**, at **15:00** in **Auditorium 103 "Assoc. Prof. Dr. Dimitar Klisarov"** at the Faculty of Dental Medicine, Medical University "Prof. Dr. Paraskev Stoyanov" – Varna, before a scientific jury composed of:

- **Chairperson:**
  Assoc. Prof. Dr. Miglena Ilieva Balcheva-Eneva, PhD – internal member

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- Assoc. Prof. Dr. Maria Dimitrova Miteva-Hristova, PhD – internal member
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- Prof. Dr. Teodora Nikolaeva Bolyarova-Konova, PhD – alternate external member
  The defense materials are available at the Scientific Department of MU-Varna and are published on the official website of MU-Varna.

Table of Content

List of abreviations

AH – Arterial Hypertension
AMI – Acute Myocardial Infarction
BM – Bacterial Microorganism Count
BMI – Body Mass Index
BoP (Bleeding on Probing) – Bleeding on Probing
CHD – Cardiovascular Diseases
CP – Chronic Periodontitis
CRP – C-Reactive Protein
CVD – Cardiovascular Diseases
DM – Diabetes Mellitus
eGFR – Estimated Glomerular Filtration Rate
HDLC – High-Density Lipoproteins
Kg – Kilogram
LDL – Low-Density Lipoproteins
M – Meter
po – Per os (Oral Administration)
PI – Peri-implantitis
PI (Plaque Index) – Plaque Index
PItissues – Peri-implant Tissues
PIMD – Peri-implant Inflammatory Diseases
PM – Peri-implant Mucositis
SYNTAXscore – Synergy Between PCI With TAXUS and Cardiac Surgery
TnI – Cardiac Troponin I

1. Introduction

Dental implantology is an innovative specialty that ensures effective and adequate rehabilitation of the masticatory system and its functions.
With the increasing use of implants in dental practice, the number of complications has also risen.
Intraoperative and postoperative complications are observed.
Postoperative complications, in turn, are divided into early and late.
Late postoperative complications include biological, aesthetic, and technical types.
Peri-implant mucositis and peri-implantitis are classified as late biological complications.
Peri-implantitis is a plaque-induced inflammatory process of the peri-implant tissues, accompanied by bone resorption (crater-shaped).
It has been proven that the pathogens responsible for periodontal diseases are identical to the bacterial species detected around implants, with a difference in microbial count: it is higher around natural teeth.
Two types of associations between peri-implant disease and cardiovascular diseases (CVD) have been identified: direct and indirect.

- **Direct**: translocation of pathogenic microorganisms from peri-implant tissues into the bloodstream and subsequently to the coronary arteries.
- **Indirect**: translocation of inflammatory cytokines from the peri-implant inflammatory site into the bloodstream and subsequently to the coronary arteries

2. Aim and Objectives

Aim:
The present dissertation aims to investigate the role of periodontal pathogens in the etiology of coronary stenosis in patients with dental implants.

Objectives:

1. To analyze the general health status and condition of the peri-implant tissues in patients who have undergone selective coronary angiography.
2. To examine the relationship between infection with *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Treponema denticola* and peri-implant inflammation.
3. To determine the correlation between peri-implant infection and the SYNTAX Score.
4. To investigate the differences in the severity of coronary artery pathology between patients with peri-implantitis and those with periodontitis.

3. Originak Research.

3.1. Materials and Methods

The study commenced following approval No. 108/25.11.2021 from the Ethics Committee for Scientific Research at the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna.

To fulfill the first objective of the research, between **December 6, 2021** and **January 24, 2024**, 200 patients were examined in the Department of Invasive Cardiology (Second Cardiology Clinic) at the University Hospital "St. Marina," affiliated with the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna.
Out of the total 200 patients, **37 cases** with dental implants met the inclusion criteria for the study titled *"Coronary Artery Pathology in Patients with Peri-implantitis."*

Patient Selection:
Selection was performed after a thorough analysis and evaluation of the indications for treatment, as well as confirmation of the absence of general and local contraindications.

Inclusion Criteria:

1. Age between 45 and 64 years
2. Sex – not relevant
3. Indications for elective or emergency coronary angiography
4. Signed informed consent

Exclusion Criteria:

1. Age < 45 or > 65 years
2. Absence of signed informed consent
3. Medical history of rheumatic fever or existing autoimmune rheumatologic disease
4. Contraindications for undergoing coronary angiography

Monitored Parameters:

1. Medical history of previous cardiovascular events
2. Comorbidities
3. Ongoing therapies
4. Anthropometric data

5. Laboratory test results
6. PCR testing
7. Periodontal/peri-implant pathology

3.1.1. Materials for Objectives 1, 2 and 3

For each patient who met the inclusion criteria and signed informed consent for the procedures, the following assessments were performed:

- Blood samples were collected for a complete blood count
- Coronary angiography was conducted
- A periodontal status evaluation was completed
- Peri-implant tissue samples were collected for PCR analysis

After filtering all examined patients according to the inclusion criteria for **Objective 1**, the following findings were established:

1. All patients with dental implants included in the study were male
2. The median age of the patients was 60 years (interquartile range: 55–64)

3.1.2.Materials for Objective 4

To fulfill **Objective 4** of the study, between **December 6, 2021** and **January 24, 2024**, a total of 200 patients were examined at the Department of Invasive Cardiology (Second Cardiology Clinic) at the University Multiprofile Hospital for Active Treatment "St. Marina," affiliated with the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna.

Out of the total cohort, **37 patients with dental implants** (Group 1) and **51 patients with natural dentition** (Group 2) met the inclusion criteria for the research titled *"Coronary Artery Pathology in Patients with Peri-implantitis."*

For each eligible patient who signed informed consent, the following were performed:

- Blood sample collection for a complete blood count
- Coronary angiography
- Periodontal status assessment
- PCR sampling from peri-implant or periodontal tissues

After filtering according to the inclusion criteria for **Objective 4**, the following findings were established:

1. All patients in both Group 1 and Group 2 were male.
2. The **median age** of patients in **Group 1** (with dental implants) was **60 years** (interquartile range: 55–64).
3. The **median age** of patients in **Group 2** (with natural teeth) was **55 years** (interquartile range: 53–58).

3.1.3 Methods for Objectives 1, 2, 3 and 4

All patients included in Objectives 1, 2, 3, and 4 were hospitalized in the Department of Invasive Cardiology (Second Cardiology Clinic) at the University Multiprofile Hospital for Active Treatment "St. Marina," affiliated with the Medical University "Prof. Dr. Paraskev Stoyanov" – Varna, for a period of **48 hours**.

Each patient was provided with individualized informational materials describing the scientific study, along with a **written informed consent form**.

Patients were entered into a dedicated database containing the following information:

1. Identification Data: The database included the patient's full name, initials, hospital case number, date of admission, and a unique patient ID.

Presented in Table 1:

Full name	**Initials**	**Case №**	**Admission Date**	**ID**

Table 1. Identification Data

2. Antropometric Data: The following parameters were recorded: age, sex (male = 0; female = 1), weight (kg), height (m), and Body Mass Index (BMI, kg/m²).

Presented in Table 2:

Age	Sex	Weight	Height	BMI
	male=0; female=1	**kg**	**m**	**kg/m²**

Table 2. Antropometric Data

3.The following parameters related to arterial hypertension (AH) were recorded for each patient:

3.1 Presence or absence of arterial hypertension
3.2 Whether the patient is undergoing regular antihypertensive treatment
3.3 Number of antihypertensive medications taken
3.4 Quality of blood pressure control – good or poor
3.5 Duration of hypertension – none, less than 5 years, 5–10 years, or more than 10 years

Presented in Table 3:

AH

Regular Treatment	No. of Medications	AH control	Duration of AH
Yes=1; No=0	**1, 2, 3, ...**	**good=1; bad=0;**	**no=0; <5 y.=1; 5-10y.=2; >10y.=3**

Table 3. AH Data

4.Diabetes Mellitus Data

4.1 Presence or absence of diabetes mellitus (DM)
4.2 Use of oral antidiabetic medications
4.3 Use of insulin therapy
4.4 Glycemic control – good or poor
4.5 Duration of diabetes – none, less than 5 years, 5–10 years, or more than 10 years

Presented in Table 4:
Diabetes Mellitus

p.o.	Insulin	DM control	Duration of DM
yes=1; no=0	yes=1; no=0	good=1; poor=0; no applicable=2	no=0; <5 y.=1; 5-10y.=2; >10y.=3

Table 4. Diabetes Mellitus Data

5.Tobacco Use Data

5.1 Current smoker status
5.2 Former smoker (quit more than 3 years ago)
5.3 Number of cigarettes per day – non-smoker, <5/day, 5–15/day, >15/day
5.4 Duration of smoking – non-smoker, <5 years, 5–10 years, >10 years

Presented in Table 5:

Tobacco Use Data

	No of Cigarettes	Duration
Former smoker >3 r. yes=1; no=0	no=0; <5 =1; 5-15=2; >15=3	no=0; <5 y.=1; 5-10y.=2; >10y.=3

Table 5. Tobacco Use Data

Each patient had blood samples collected for the evaluation of general health status, including:

6. Lipid Profile and Statin:Total cholesterol (mmol/L), LDL-C (Low-Density Lipoprotein Cholesterol) (mmol/L), HDL-C (High-Density Lipoprotein Cholesterol) (mmol/L), use of statins

Presented in Table 6:

Total Cholesterol	**LDL-C**	**HDL-C**	**Statin Use**
mmol/L	**mmol/L**	**mmol/L**	**yes=1; no=0**

Table 6. Lipid Profile and Statin Therapy

5. Inflammatory Markers: CRP(mg/L), Tnl, 3 – glycerides(mmol/L) and use of fibrates.

Presented in Table 7:

CRP	**TnI**	**3-glycerides**	**Fibrates**
mg/L	**ng/mL**	**mmol/L**	**yes=1; no=0**

Table 7. Datas for CRP, TnI, 3 – glycerides and fibrates

6. Each patient underwent evaluation of renal function, including:

   8.1 Serum creatinine levels (μmol/L)

1. Duration of chronic kidney disease (CKD)
2. eGFR – estimated glomerul filtration rate (ml/min/1.73m²)

Presented in Table 8:

Renal Function Parameters

Creatinine	CKD Duration	eGFR
mcmol/L	no=0; <5 y.=1; 5-10 y.=2; >10y.=3	ml/min/1.73m2

Table 8. Renal Function Parameters

7. Duration of Angina Pectoris: Patients were asked whether they had a history of angina pectoris. If present, the duration was recorded in years; if not, the value was recorded as **0**.

Angina Pectoris
Yes=duration in years; No=0

8. History of Ischemic Events: Anamnesis was collected from each patient regarding past ischemic cardiac events:

   10.1 **Myocardial Infarction (MI):** Whether the patient had a previous MI. If yes, the number of years since the event was recorded.
   10.2 **Percutaneous Coronary Intervention (PCI):** Whether PCI had been performed. If yes, the duration since the **first procedure** was recorded.

10.3 **Coronary Artery Bypass Grafting (CABG):** Whether CABG had been performed. If yes, the number of years since the **first surgery** was recorded.

Presented in Table 9:

History of Ischemic Events

Myocardial Infarction	**PCI**	**CABG**
No=0; Yes= Duration in years	**No=0; Yes=years since first PCI**	**No=0; Yes=years since first CABG**

Table 9. Histort of Ischemic Events

9. Indications for Invasive Coronary Diagnostics: Each patient was classified according to the clinical indication for undergoing invasive diagnostic

11.1 Angina pectoris

11.2 Non-ST elevation acute coronary syndrome (NSTE-ACS)

11.3 ST elevation acute coronary syndrome (STE-ACS)

11.4 Valve replacement

Presented in Table 10:
Indications for Invasive Coronary Diagostics

Angina Pectoris	**NSTE - ACS**	**STE - ACS**	**Valve Replacement**
да=1; не=0	**да=1; не=0**	**да=1; не=0**	**да=1 ; не=0**

Table 10. I*ndications for Invasive Coronary Diagostics*

10. Coronary Anatomy Evaluation
    12.1 SCAG – Report number and date
    12.2 **LM (Left Main):** Maximum degree of stenosis (%)
    12.3 **LAD (Left Anterior Descending):** Maximum degree of stenosis (%)
    12.4 **RCx (Left Circumflex):** Maximum degree of stenosis (%)
    12.5 **RCA (Right Coronary Artery):** Maximum degree of stenosis (%)
    12.6 **Presence of Thrombosis** – Yes/No
    12.7 **Slow Flow** phenomenon – Yes/No
    12.8 **Diffuse Coronary Disease** – Yes/No
    12.9 **Atonic Vessel Changes** – Yes/No
    12.10 **SYNTAX Score I** – Calculated using standard protocol

Presented in Table 11:

Coronary Anatomy Parameters

SCAG № .../дата. SYNTAX score I

LM	LAD	RCx	RCA	Thrombosis	SlowFlow	Дифузна болест	Атонични промени
% max stenosis	% max stenosis	% max stenosis	% max stenosis	yes=1; no=0	yes=1; no=0	yes=1; no=0	yes=1; no=0

Table 11. ***Coronary Anatomy Parameters***

The coronary anatomy was assessed using coronary angiography, performed with the device shown in Figure 1.

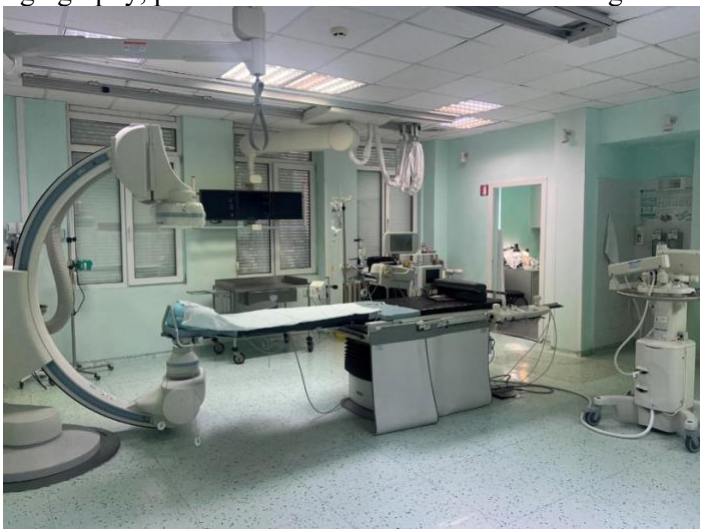


Figure 1. Angiograph

All 12 clinical and laboratory components described above were used to assess the **general health status** of each patient.
After collecting this baseline data, a **periodontal status** evaluation was conducted, and samples for **PCR microbiological analysis** were obtained.

To assess the periodontal and peri-implant health of each patient, the following indices were recorded:

- **Gingival Index** (Bleeding on Probing, BoP)
- **Plaque Index (PI)**
- **Comprehensive periodontal status**

Each patient received an individualized **periodontal chart** including the following administrative data:

1. Full name of the patient
2. Age
3. Name of the examining dentist
4. Date of examination and individual patient ID
5. Type of visit: initial examination or re-evaluation

The periodontal chart was divided into four quadrants:

1. Buccal surface of the maxillary teeth
2. Palatal surface of the maxillary teeth
3. Lingual surface of the mandibular teeth
4. Buccal surface of the mandibular teeth

Each quadrant included clinical data per tooth as follows:

1. Tooth mobility

2. Presence or absence of a dental implant
3. Furcation involvement
4. Bleeding on probing
5. Dental plaque
6. Level of the gingival margin (margo gingivalis)
7. Probing depth

The **BoP index** used in this study follows the protocol of Ainamo & Bay (1975) and is designed to assess the **presence or absence of inflammation** in periodontal and peri-implant tissues.

All available teeth were examined at six sites per tooth:

- **Mandible**: disto-vestibular (DV), vestibular (V), mesio-vestibular (MV), disto-lingual (DL), lingual (L), mesio-lingual (ML)
- **Maxilla**: DV, V, MV, disto-palatal (DP), palatal (P), mesio-palatal (MP)

The examination was performed using a **UNC-15 periodontal probe**, introduced with sweeping movements to the base of the sulcus/pocket. After **15 seconds**, bleeding was recorded.

- Presence of bleeding was marked as "+"
- Absence of bleeding was marked as "–"

Each tooth/implant received **six entries** in the chart.

Calculation formula:

$$Ainamo\&Bay = \frac{all\ amount\ of\ \ "+"}{\text{all examined surfaces}}\ x\ 100$$

Interpretation:

- ≤10% – Healthy
- 10–30% – Localized inflammatory process
- 30% – Generalized inflammatory process

The **Plaque Control Index (PI)** used is that of O'Leary (1972), assessing the **presence or absence of plaque** on tooth surfaces.

As with BoP, each tooth was evaluated at six sites:

- Mandible: DV, V, MV, DL, L, ML
- Maxilla: DV, V, MV, DP, P, MP

The examination was carried out via **visual inspection** and probing with the UNC-15 probe.

- Presence of plaque was recorded with "+"
- Absence with "–"

Each tooth/implant had six recorded entries.

Calculation formula:

$$O'Leary = \frac{all\ amount\ of\ "+"}{\text{all examined surfaces}}\ x\ 100$$

Interpretation:

- ≤10% – Healthy
- 10–30% – Non-plaque-induced inflammation
- 30% – Plaque-induced inflammation

The **UNC-15 periodontal probe** used in this study consists of a handle, shank, and a calibrated working tip with an **atraumatic**

rounded end.
The tip is **color-coded at each millimeter** from 1 to 15 mm.
Distinctive black bands are located at:

- 4–5 mm
- 9–10 mm
- 14–15 mm

The instrument is shown in **Figure 2**.

Table 2. Periodontal probe UNC - 15

The **gingival margin level (margo gingivalis)** was measured at six sites per tooth:

- **Mandible**: DV, V, MV, DL, L, ML
- **Maxilla**: DV, V, MV, DP, P, MP

The distance was recorded in **millimeters**, measured from the **cementoenamel junction (CEJ)** to the **gingival margin**using a **UNC-15 periodontal probe**. Three conditions were identified:

1. **Gingival margin located coronally to the CEJ** – considered physiological, unless pseudopocketing is present.
2. **Gingival margin located apically to the CEJ** – defined as **gingival recession** and noted in the chart with a minus sign "–" before the measurement.
3. **Gingival margin at the level of the CEJ** – recorded as "0" in the chart.

Probing depth was measured on each tooth at six sites (as listed above). The distance from the **gingival margin** to the **base of the periodontal/peri-implant sulcus or pocket** was recorded in millimeters using the **UNC-15 probe**. The probe was inserted parallel to the long axis of the tooth, applying light resistance (approx. 20–25g or 0.20–0.25 N), and moved circumferentially around the crown in 1 mm steps, with a vertical sweep of 1–2 mm. Interproximally, the probe was gently angled toward the contact point.

Together with the **Ainamo & Bay Index**, the probing depth values were used to diagnose:

- Gingivitis
- Periodontitis
- Peri-mucositis
- Peri-implantitis

Tooth mobility was assessed using the **Miller Classification**:

- **Grade 0** – Physiological mobility (up to 0.1–0.2 mm)
- **Grade 1** – Up to 1 mm horizontal mobility
- **Grade 2** – More than 1 mm horizontal mobility

- **Grade 3** – Horizontal and vertical mobility

The examination was performed using the handles of two instruments placed vestibularly and orally. Gentle alternating pressure was applied. One **numeric value per tooth** was recorded in the periodontal chart.

Furcation involvement was examined using **Nabers probes**:

- **Nabers 1** – Maxilla
- **Nabers 2** – Mandible

Only **multi-rooted teeth** were evaluated:

- **Maxillary first premolars**: two furcation entrances (MP, DP)
- **Maxillary molars**: three entrances – buccal (V), mesio-palatal (MP), and disto-palatal (DP)
- **Mandibular molars**: two entrances – buccal (V) and lingual (L)

Hamp Classification:

- **F0** – No furcation involvement
- **F1** – Horizontal bone loss ≤3 mm
- **F2** – Horizontal bone loss >3 mm, not through-and-through
- **F3** – Through-and-through furcation involvement

Tarnow & Fletcher subclassification (1984) was applied using radiographs or surgical flap reflection to assess **vertical bone loss**:

- **Class A** – Bone loss ≤3 mm
- **Class B** – 3–6 mm
- **Class C** – >6 mm

Values were recorded in the chart using appropriate codes per site.

The presence or absence of a **dental implant** was recorded **once per tooth position** in the periodontal chart.

After full periodontal assessment, samples were collected from the **most affected periodontal/peri-implant sites** using a **real-time PCR test (MIP-Pharma)**.

The test included detection of:

- **PET Standard Panel**
- **Total bacterial load (Bacterial Microorganism Count, BM)**

PCR Sample Collection Kit Included:

1. Patient information form (name, age, address), physician data (name, email), and site details (tooth/implant position and pocket depth in mm)
2. Five sterile paper points
3. A sterile plastic container for pooled samples

Sampling Procedure:
Using tweezers, a sterile paper point was inserted into the base of the pocket and left in place for **15 seconds**, then placed into the container. This was repeated for five sites, avoiding contamination with saliva.

Packaging and Shipment:
After sampling, the container and completed form were sealed in a shipping envelope and sent for analysis to:
Kirkeler Straße 41, D-66440 Blieskastel–Niederwürzbach, Germany

The **sampling kit** used for real-time PCR is presented in **Figure 3**.

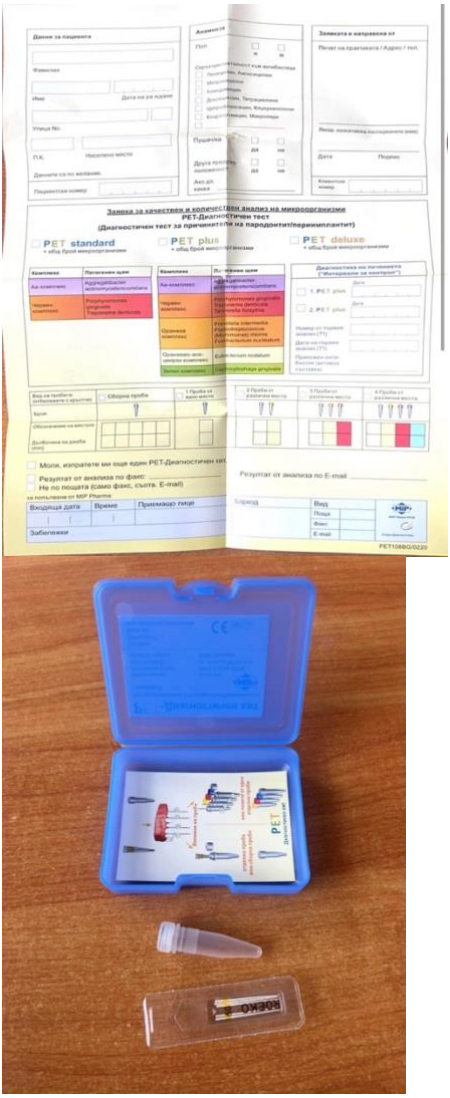


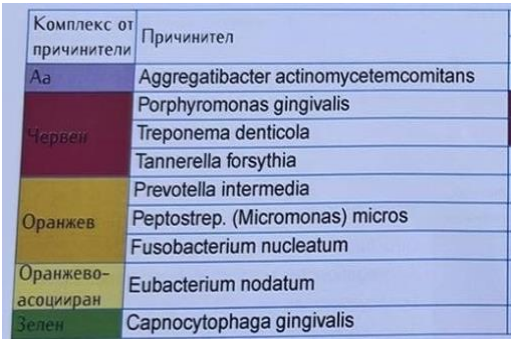
Figure 3. Real – Time PCR Sampling Kint and Data Entry Form

The results obtained from the **real-time PCR microbiological testing** included the following components:

1. **Patient Information** – full name, age, ID number.
2. **Practice/Clinic Information** – name of referring physician and practice contact details.
3. **Type of PET Diagnostic Test** – *PET Standard*, which provides **exact microbial counts** for:
    - *Porphyromonas gingivalis*
    - *Aggregatibacter actinomycetemcomitans*
    - *Treponema denticola*

    as well as the **total number of detected microorganisms** (*see Figure 16*).
4. **Table of Detected Pathogens** – including:
    - Identified species in the sample
    - Percentage of each pathogen
    - Associated microbial complexes
    - Classification by pathogen group
5. **Technical and Administrative Details**:
    - Date of sample receipt
    - Sample request number
    - Analysis number
    - Date of analysis
    - Date of issued report
    - Signature of laboratory director
6. **Microbial Load Table**, reporting the quantity of each identified microorganism, using the following scale:
    - +++ – high bacterial load
    - ++ – moderate bacterial load
    - + – low bacterial load
    - – – microorganism not detected

The **total microbial count** includes organisms grouped into **five microbial complexes**, illustrated in **Figure 4**.



Комплекс от причинители	Причинител
Аа	Aggregatibacter actinomycetemcomitans
Червен	Porphyromonas gingivalis
	Treponema denticola
	Tannerella forsythia
Оранжев	Prevotella intermedia
	Peptostrep. (Micromonas) micros
	Fusobacterium nucleatum
Оранжево-асоцииран	Eubacterium nodatum
Зелен	Capnocytophaga gingivalis

Figure 4. Microbial Complexes and Their Represantative Soecies

3.1.4. Statistical Methods

The following statistical methods were used for processing and analyzing the data from the study:

1. Descriptive Analysis

1.1 **Alternative analysis** – applied to describe qualitative variables and grouped data.
1.2 **Variation analysis** – applied to describe quantitative variables.

Results were presented using **measures of central tendency** (mean, median) and **measures of dispersion** (standard deviation, interquartile range [IQR], range), depending on the distribution of the data.

2. Hypothesis Testing

2.1 Parametric Methods – applied when quantitative variables followed a normal distribution:

- **Student's t-test** – for testing hypotheses regarding significant differences between two dependent or independent samples
- **Pearson correlation analysis** – for assessing linear relationships between normally distributed variables

2.2 Non-Parametric Methods – used for variables that deviate from normal distribution or for qualitative variables:

- **Mann–Whitney U test** – for comparing two independent samples
- **Pearson's Chi-square (χ^2) test** – for categorical variables in contingency tables
- **Spearman's rank correlation analysis** – for evaluating monotonic relationships between non-normally distributed variables
- **Fisher's exact test** – for testing associations between categorical variables in small sample sizes
- **Kendall's Tau (τ)** – a non-parametric correlation coefficient used to measure the strength and direction of monotonic association between two ranked variables

3. Tabular and Graphical Methods

Results were visualized using tables, bar charts, box plots, andscatter plots where appropriate. **Data analysis was performed using:**

- **IBM SPSS Statistics**, version 25.0 (Chicago, IL, USA)
- **Jamovi Statistical Software**
- **Microsoft Excel 2013** – for graphical presentations

3.2. Results, analysis and discussion of the Objectives

3.2.1. Discussion, analysis and discussion – Objective 1

From the analysis of the results under Task – 1, it was found that all examined patients are overweight, with an average height above the national average and are classified as pre-obese.

*Presented in **Table – 12**.*

Ch-cs	N	Median	Q1	Q3	Min	Max
Age, years.	37	60	55	64	47	64
Weight, kg.	37	97	88	104	85	118
Height, m..	37	1,8	1,8	1,8	1,8	1,9
BMI	37	29,22	27,16	31,5	23,55	35,15

Table – 12. Analysis of the general health status of patients with dental implants

Regarding the general health condition of the patients, it can be concluded that all suffer from arterial hypertension, with the highest percentage of patients having had it for more than 10 years, receiving regular treatment with good control through the intake of three medications. **83,8%** of the examined patients have angina pectoris. No patient was found to have experienced a myocardial infarction or undergone coronary artery bypass surgery. A higher percentage (73%) of the patients do not have diabetes mellitus. Among the

patients with diabetes mellitus, the duration of the disease is mostly between 5–10 years, and all of them are on oral therapy; none are on insulin. The diabetes control is good in 73,9% of the diabetic patients. ($\chi^2 = 28,8$, $p < 0,001$)

*Presented in **Table – 13***

Ch-cs	Category	N	%	CI 95%		p
				Lower	Upper	
Diabetes	No	27	73,0%	27,1%	60,5%	χ2=7,81 , p=0,005
	Yes	10	27,0%	39,5%	72,90%	
Duration of DM	No	27	73,0%	55,9%	86,2%	p (Exact test) <0 ,001
	<5 y.	3	8,1%	1,7%	21,9%	
	5-10y.	7	18,9%	8,00%	35,2%	
P.o. therapy	No	27	0,73	55,9%	86,2%	χ2=7,81 , p=0,005
	Yes	10	0,27	13,8%	44,1%	
Insuline use	No	37	100%			
Diabetes control	Poor	1	2,7%	0,0%	14,2%	χ2=28,8 , p< 0,001
	Good	9	24,3%	11,8%	41,2%	
	No	27	72,9%	55,9%	86,2%	

Table – 13. Analysis of Diabetes Mellitus: duration, therapy, insulin use, control

Regarding the harmful habit of smoking, the majority of patients are non-smokers. **54,1 %** of the patients reported being former smokers for over 3 years. Among the current smokers, **72,7%** smoke between 5–15 cigarettes per day. ($\chi^2 = 2.27$, $p = 0.13$)

*Presented in **Table – 14***

Ch-cs	Category	N	%	CI 95%	
				Lower	Upper
Smoking	No	26	70,3%	53,0%	84,1%
	Yes	11	29,7%	15,9%	47,0%
Former smoker (преди >3 г)	No	17	45,9%	29,5%	63,1%
	Yes	20	54,1%	36,9%	70,5%
Cigarettes per day (current smokers)	5-15 cig./day	8	72,7%	39,0%	94,0%
	Over 15 cig./day	3	27,3%	6,0%	61,0%

Table – 14. Analysis of the harmful habit of smoking

From the examination of the lipid profile (cholesterol, LDL-C, HDL-C, triglycerides), it was found that all parameters are within normal limits, with the exception of HDL-C, which indicates a moderate risk with a value of **1,24 mmol/L**(reference values: 0.90–1.45 mmol/L). The favorable lipid profile in patients is attributed to the fact that **75,7%** of the patients are taking statins, and none are taking fibrates. It is considered that statins control LDL cholesterol, while fibrates affect triglycerides and HDL cholesterol—this has also been established by other authors (126).

The CRP marker is within the normal range: **mean value: 1 mg/L** (reference range: 0,7–1,5 mg/L). The troponin I (TnI) marker is also within normal limits: **mean value: 0,2 ng/mL** (reference range: 0–0,2 ng/mL), confirming that none of the patients have experienced a myocardial infarction or acute coronary syndrome.

From the study of the **renal function** of the patients, it was found that the **creatinine** level had a **mean value of 85 µmol/L** (reference values for males over 15 years: 62–106 µmol/L), which is considered normal.
The **mean values of eGFR** are **79.7 ml/min/1.73 m²** (reference

values: 52.64–83.2 ml/min/1.73 m²). These values indicate an early stage of kidney disease that has not been investigated so far.

*Presented in **Table – 15**.*

Ch-cs	N	Me	IQR		Min	Max
			Q1	Q3		
Creatinine **µmol/l**	37	85	81	127	78	127
eGFR ml/min/1,73m^3	37	79,7	52,64	83,2	52,64	97,53

Table – 15. Analysis of renal function - creatinine, eGRF

Regarding the **indications for invasive diagnostics**, most patients (64,9%) presented with **angina pectoris**, **24,3%** had **non-ST-elevation acute coronary syndrome**, and **10,8%** had **ST-elevation acute coronary syndrome**.

The majority of the examined patients had **no thrombosis**, **no Slow Flow**, **no diffuse disease**, or **no atherogenic changes**.

All examined patients showed a **high total microbial count (6,300 × 10⁶)**. The detected amount of **T. denticola (210 × 10³)** was significantly higher than that of **P. gingivalis (32 × 10³)**, which is also confirmed in scientific articles.

The **highest percentage (43,2%)** of **P. gingivalis** was found with a **moderate level of contamination**, while the **highest percentage (67,6%)** of **T. denticola** was found with a **high level of contamination**.

*Presented in **Table – 16**.*

Ch-cs	N	Median	Q1	Q3	IQR	Min	Max
Total number of microorganisms (10^6)	37	6300	520	13000	12480	64	2900000,00
P.gingivalis (10^3)	37	32	0,99	62	61,01	0	550000,00
T.denticola (10^3)	37	210	0,99	62	61,01	0	39000,00

Table – 16. Analysis of total microbial count, P.gingivalis and T,denticola

Both indices—**Ainamo & Bay** (BoP, gingival index): **98%**, and **O'Leary** (plaque index): **74%**—are above the normal range, which is also confirmed by other authors (1, 4, 17, 50).

*Presented in **Table – 17**.*

Ch-cs	N	Median	Q1	Q3	IQR	Min	Max
GI - Ainamo&Bay, %	37	95	89	100	11	10	100
PlI - O'Leary, %	37	74	89	100	11	10	100

Table – 17. Analysis of gingival and plaque indeces

The examined patients predominantly presented with a **generalized, plaque-induced inflammatory process** of the peri-implant tissues. ($\chi^2 = 47{,}4$, $p < 0{,}001$), a test with very high statistical significance.

Presented in **Table – 18**

GI - degree	N	%	χ^2	p
Norm	4	10,8%		
Localized form of inflammation	1	2,7%		
Generalized form of inflammation	32	86,5%		
O'Leary	N	%	47,4	< 0,001
Norm	4	10,8%		
Non-plaque-induced inflammation	1	2,7%		
Plaque-induced inflammation	32	86,5%		

Table – 18. Analysis of Ainamo&Bay and O'Leary indices

The **mean probing depth (PD)** is **3,60 mm**.

*Presented in **Table – 19**.*

Ch-cs	N	Median	Q1	Q3	IQR	Min	Max
Mean PD,mm.	37	3,17	2,5	4,33	2,83	2,83	8,33

Table – 19. Mean probing depth of peri-implant tissues

The greater percentage (**86,5%**) of patients were diagnosed with **peri-implantitis**, followed by a diagnosis of **peri-implant mucositis** (**13,5%** of patients). ($\chi^2 = 1.03$, $p = 0,598$)

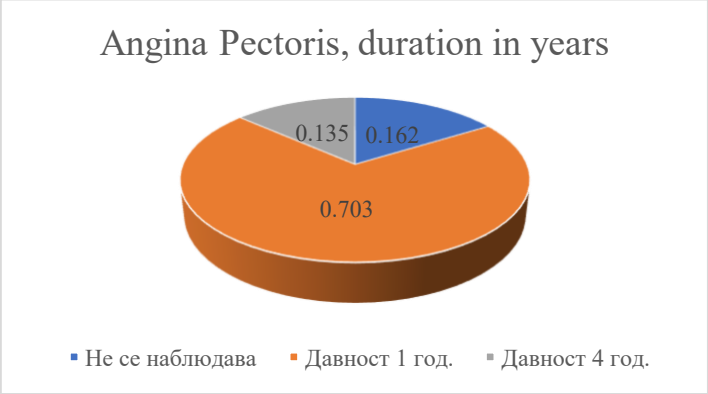
*Presented in **Table – 20***

Ch-cs	Категории	N	%	χ^2	p
Diagnosis	Peri-implantitis	32	86,5%	19,7	< 0,001
	Peri-mucositis	5	13,5%		
Implants with BOP&PPD	≤ 3мм	10	27,0%	1,3	0,598
	4-5 мм	15	40.5%		
	над 5 мм	12	32.4%		

Table – 20. Analysis of peri-implant inflammation

The results show that **31 patients (83.8%)** have **angina pectoris** ($\chi^2 = 16.9$, $p < 0.001$), of which **26 patients (70%)** have had it for **one year**, and **5 patients (13.5%)** have had it for **over four years**.

*Presented in **Figure – 5**.*



Фигура 5. Duration of Angina Pectoris in years

3.2.2. Discussion, analysis and discussion – Objective 2

The greatest involvement of peri-implant tissues (total number of PD ≤ 3 mm, PD = 4–5 mm, and PD > 5 mm) was observed in the **molar region**. The **second most affected** was the **anterior region**, while the **least involvement** was observed in the **premolar region**.

Most scientific articles categorize the **molar and premolar regions** as the most affected.

The most commonly measured PD across all three regions was **4–5 mm**, followed by PD > 5 mm, while PD ≤ 3 mm was the least observed. (Fisher's exact test, p = 0.843)

*Presented in **Table – 21**.*

Probing Depth	**≤ 3 mm**		**4-5 mm**		**Above 5 mm**		**Total**		**p (Fisher's exact test)**
Tooth type	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Molar	3	18,8 %	7	43,8 %	6	37,5 %	16	100,0 %	0,843
Premolar	4	36,4 %	3	27,3 %	3	30,0 %	10	100,0 %	
Anterior	3	30,0 %	5	50,0 %	3	27,3 %	11	100,0 %	
Total	10	27,0 %	15	40,5 %	12	32,5 %	37	100,0 %	

Table 21. Distribution of probin depth by tooth group

A very strong, **positive and statistically significant correlation** was observed between **Ainamo & Bay (BoP)** and **total number of microorganisms**. (Spearman's $\rho = 0{,}837$, $p < 0{,}001$). A similarly strong, **positive correlation** was found between **O'Leary (plaque index)** and the **total number of microorganisms**. (Spearman's $\rho = 0{,}727$, $p < 0{,}001$).

An **extremely strong correlation** was observed between the **gingival index (Ainamo & Bay)** and the **plaque index (O'Leary)** (Spearman's $\rho = 0{,}946$, $p < 0{,}001$).

*Presented in **Table – 22**.*

Ch-cs	**Stat.Test p**	**Total microorganisms/1 000000**	**PlI - O'Leary**	**GI - Ainamo& Bay**
PlI - O'Leary	Spearman's ρ(rho)	0,727	—	
	p-value	< 0,001	—	
GI - Ainamo& Bay	Spearman'sρ (rho)	0,837	0,946	—
	p-value	< 0,001	< 0,001	—
Mean PD, mm.	Pearson r	0,384	0,202	0,337
	p-value	0,019	0,231	0,042

Table 22. Correlation between gingival and plaque indices, mean probing depth, and total microorganism count

- A **statistically significant moderate positive correlation** was found between the **contamination levels** of the two bacterial species
(Kendall's Tau B = 0,321, p = 0,005)

- A **very strong, statistically significant correlation** was found between **T. denticola contamination level** and the **Ainamo & Bay index (BoP)**
(Kendall's Tau B = 0,531, p < 0,001)

- A **very strong, statistically significant correlation** was also found between **T. denticola** and the **O'Leary index (plaque index)**
(Kendall's Tau B = 0,631, p < 0,001)

- A **very strong negative statistically significant correlation** was observed between **P. gingivalis contamination**and **presence of peri-mucositis**
(Kendall's Tau B = –0,516, p < 0,001)

- A **positive correlation** was observed between **P. gingivalis contamination** and **presence of peri-implantitis**
(Kendall's Tau B = 0,516, p < 0,001)

- A **negative correlation** was found between **P. gingivalis contamination** and **BOP & PPD ≤ 3 mm**
(Kendall's Tau B = –0,297, p = 0,01)

- A **positive correlation** was found between **P. gingivalis contamination** and **BOP & PPD = 4–5 mm**
(Kendall's Tau B = 0,271, p < 0,018)

- With **T. denticola**, the opposite pattern was observed:

- A **non-significant correlation** between **T. denticola** and **peri-mucositis** (Kendall's Tau B = 0,117, p = 0,308)

- A **non-significant negative correlation** between **T. denticola** and **peri-implantitis (BOP & PPD = 4–5 mm)** (Kendall's Tau B = –0,117, p = 0,308)

- A **non-significant positive correlation** between **T. denticola** and **BOP & PPD ≤ 3 mm** (Kendall's Tau B = 0,14, p = 0,222)
-
- A **non-significant negative correlation** between **T. denticola** and **BOP & PPD = 4–5 mm** (Kendall's Tau B = –0,163, p = 0,155)

- **For BOP & PPD > 5 mm**, both microorganisms—**P. gingivalis** and **T. denticola**—were isolated.
  With increasing **probing depth**, the **microbial count** also increases.

*Presented in **Tables – 23 and 24***

Ch-cs	Stat.Test p	Level of contamination by Por. Ging	Level of contamination by T.denticola
Contamination by T.denticola	Kendall's Tau	0,321	—
	p	0,005	—
GI - Degree	Kendall's Tau	-0,029	0,531
	p	0,804	<,001
PlI - O'Leary-Degree	Kendall's Tau	-0,079	0,631
	p	0,489	<,001

Table 23. . Correlation between contamination level and indices

Ch-cs	Stat.Test p	Level of contamination by Por. Ging	Level of contamination by T.denticola
Pocket Depth	Kendall's Tau	0,164	-0,047
	p	0,154	0,685
Peri-mucositis	Spearman's ρ(rho)	-0,516	0,121
	p	0,001	0,475
Peri-implantitis	Spearman's ρ(rho)	0,516	-0,121
	p	0,001	0,475
Implants with BOP&PPD ≤ 3мм	Spearman's ρ(rho)	-0,322	0,145
	p	0,052	0,392
Implants with BOP&PPD 4-5 мм	Spearman's ρ(rho)	0,294	-0,169
	p	0,077	0,318
Implants with BOP&PPD над 5 мм	Spearman's ρ(rho)	-0,003	0,039
	p	0,987	0,817

Table 24. Correlation between contamination levels and peri-implant tissues

T. denticola was **not observed with a contamination grade of zero**, in contrast to *P. gingivalis*.

The **most common finding** was **grade 3 contamination** with *T. denticola*, most frequently observed in the **molar region**, followed by the **premolar region**, and least in the **anterior region**, which is consistent with the scientific literature. (p (Fisher's exact test) = 0,155)

*Presented in **Table 25**.*

Tooth type					
Level of contamination by T.denticola	**Stat.Test p**	**Molar**	**Premolar**	**Anteruon**	**Total**
1	Observation	0	2	2	4
	%	0,0 %	50,0 %	50,0 %	100,0 %
2	Observation	6	1	1	8
	%	75,0 %	12,5 %	12,5 %	100,0 %
3	Observation	10	8	7	25
	%	40,0 %	32,0 %	28,0 %	100,0 %
Total	Observation	16	11	10	37
	%	43,2 %	29,7 %	27,0 %	100,0 %

Table 25. Level of contamination by T.denticola

P. gingivalis was **most frequently observed with grade 2 contamination**.

The **anterior region** was the most affected, followed by the **molar** and **premolar** regions, with an equal number of cases.

Grade 0 contamination was observed most in the **premolar area**, followed by the **molar area**, and least in the **anterior region**.

Grade 3 contamination was observed in **only 8 cases**, **5 of which were in the molar region**, which contrasts with studies identifying the molar area as the most affected.
(p (Fisher's exact test) = 0,136)

*Presented in **Table 26**.*

Level of contamination by P.gingivalis	Tooth type							
	Molar		Premolar		Antrior		Total	
	n	%	n	%	n	%	n	%
0	3	37.5 %	4	50,0 %	1	12,5 %	8	100,0 %
1	4	80,0 %	1	20,0 %	0	0,0 %	5	100,0 %
2	4	25,0 %	4	25,0 %	8	50,0 %	16	100,0 %
3	5	62,5 %	2	25,0 %	1	12,5 %	8	100,0 %
Total	16	43,2 %	11	29,7 %	10	27,0 %	37	100,0 %

Table 26. Level of contamination by P.gingivalis

The **combined contamination by *T. denticola* and *P. gingivalis*** was detected in **all tooth groups**, **most frequently in the molar region**.
The **quantity of both microorganisms increases with the increase in probing depth**, which is consistent with findings from other studies (10).

3.2.3. Discussion, analysis and discussion – Objective 3

A **very strong, positive, and statistically significant correlation** was observed between the **contamination level with *T. denticola*** and **SYNTAX score I**. (Spearman's ρ = 0,551, p = 0,001), As well as a **moderate positive correlation** between ***P. gingivalis*** and **SYNTAX score I**. (Spearman's ρ = 0,487, p = 0,002).

In some studies, a statistically significant relationship has also been demonstrated between the two microorganisms and SYNTAX score I, but **our study shows greater significance for *T. denticola***.

*Presented in **Table 27**.*

Ch-cs	**Stat.Test p**	**Level of contamination by P.gingivalis**	**Level of contamination by T.denticola**
Level of contamination by T.denticola	Spearman's ρ(rho)	0,382	—
	p-value	0,02	—
SYNTAX score I	Spearman's ρ(rho)	0,487	0,551
	p-value	0,002	< 0,001

Table 27. Correlation between SYNTAX score I and contamination levels

Among **patients with diabetes mellitus**, the **most frequent cases** involved **grade 3 contamination with *P. gingivalis***, followed

by grade 1.

No diabetic patients were observed with **grade 0 contamination**, i.e., in our study as well, a **higher contamination level** was found in patients with diabetes mellitus (16). (Fisher's exact test $p < 0,046$)

*Presented in **Table 28**.*

Ch-cs		Level of contamination by P.gingivalis				
DM	**Stat.Test p**	**0**	**1**	**2**	**3**	**Total**
No	Observation	8	1	16	2	27
	%	29,6 %	3,7 %	59,3 %	7,4 %	100,0 %
Yes	Observation	0	4	0	6	10
	%	0,0 %	40,0 %	0,0 %	60,0 %	100,0 %
Total	Observation	8	5	16	8	37
	%	21,6 %	13,5 %	43,2 %	21,6 %	100,0 %

Table 28. Correlation between DM and contamination level with P.gingivalis

Among **patients with diabetes mellitus**, the **most frequent cases** involved **grade 3 contamination with *T. denticola***, followed by grade 2.

No cases of **grade 1 or grade 0** contamination were observed.

Unlike other studies, which found **no relationship** between *T. denticola* contamination and diabetes mellitus, **our study identified a very strong statistical association**. (Fisher's exact test $p < 0,001$ – test with very high statistical significance)

*Presented in **Table 29**.*

Ch-cs		Level of contamination by T.denticola			
DM	**Stat.Test p**	**1**	**2**	**3**	**Total**
No	Observation	4	5	18	27
	%	14,8 %	18,5 %	66,7 %	100,0 %
Yes	Observation	0	3	7	10
	%	0,0 %	30,0 %	70,0 %	100,0 %
Total	Observation	4	8	25	37
	%	10,8 %	21,6 %	67,6 %	100,0 %

Table 29. Correlation between DM and contamination level with T.denticola

Patients with diabetes mellitus have **higher contamination levels** with both *P. gingivalis* and *T. denticola* compared to healthy patients—
a conclusion that is supported by scientific literature (references 50, 98).

Among **non-smoking patients**, a **higher number of cases with grade 3 contamination** with *P. gingivalis* and *T. denticola* is observed,
compared to smokers, which **contrasts with earlier studies**.
In the **past 5–6 years**, some studies have confirmed that **smoking may reduce total microbial count**.

Among patients who are **smokers**, a **higher amount of grade 3 contamination with *T. denticola*** is observed,
whereas **not a single case** of grade 3 contamination with *P. gingivalis* is seen.
P. gingivalis – Fisher's exact test **p < 0,05** – **statistically significant**.
T. denticola – Fisher's exact test **p = 0,003**.

*Presented in **Tables 30 and 31**.*

Ch-cs		Level of contamination by P.gingivalis				
Smoking		**0**	**1**	**2**	**3**	**Total**
No	Observational	4	2	12	8	26
	%	15,4 %	7,7 %	46,2 %	30,8 %	100,0 %
Yes	Observational	4	3	4	0	11
	%	36,4 %	27,3 %	36,4 %	0,0 %	100,0 %
Total	Observational	8	5	16	8	37
	%	21,6 %	13,5 %	43,2 %	21,6 %	100,0 %

Table 30. Correlation between smoking and contamination level with P.gingivalis

Ch-cs		Level of contamination by T.denticola			
Smoking		**1**	**2**	**3**	**Total**
No	Observational	0	5	21	26
	%	0,0 %	19,2 %	80,8 %	100,0 %
Yes	Observational	4	3	4	11
	%	36,4 %	27,3 %	36,4 %	100,0 %
Total	Observational	4	8	25	37
	%	10,8 %	21,6 %	67,6 %	100,0 %

Table 31. Correlation between smoking and contamination level with T,denticola

Smoking patients exhibit **greater contamination with *T. denticola*** compared to *P. gingivalis*,
a finding that has also been reported by other authors.

In patients with dental implants, **involvement is primarily observed in the right coronary arteries** (**RCA** and **RCx**).
The **most affected coronary artery** (with the greatest obstruction) is **RCx**, with **80%**.

*Presented in **Table 32**.*

Ch-cs	N	Me	IQR		Min	Max
			Q1	Q3		
LM, %	37	0%	0%	0%	0%	0%
LAD, %	37	20%	0%	90%	0%	90%
RCx, %	37	80%	0%	100%	0%	100%
RCA, %	37	75%	0%	100%	0%	100%
SYNTAX score I	37	7	0	33,5	0	0,335

Table 32. Analysis of coronary artery involvement and SYNTAX Score I

3.2.4. Discussion, analysis and discussion – Objective 4

From the analysis of the general health status of patients with implants (Group 1) and patients without implants (Group 2), the following was found:

- The median age of patients with implants is 60 years (55; 64).
- The median age of patients without implants is 55 years (53; 68).
  (p Mann–Whitney U test = 0.001)
- The average weight of patients in Group 1, measured in kilograms, is 97 kg (88; 104), which is above the average weight of men in Bulgaria (79 kg).
- The average weight of patients in Group 2, measured in kilograms, is 97 kg (80; 105), which is also above the average weight of men in Bulgaria (79 kg).
  (p Mann–Whitney U test = 0.418)
- The height, measured in meters, of patients in Group 1 is 1.8 m (1.8; 1.9), which is above the average height for men in Bulgaria (1.74 m).
- The height, measured in meters, of patients in Group 2 is 1.74 m (1.7; 1.8), which equals the average height for men in Bulgaria (1.74 m).
  (p Mann–Whitney U test < 0.001)
- BMI (kg/m²) of patients in Group 1 is 29.22 kg/m² (27.16; 31.05), indicating that patients are overweight.
- BMI (kg/m²) of patients in Group 2 is 29.94 kg/m² (26.12; 35.06), also indicating overweight.
  (p Mann–Whitney U test = 0.432)

Presented in Table 33.

Ch-cs	Group	N	Median	Q1	Q3	Min	Max	p (Mann-Whitney U test)
Age, years	Group – 1	37	60	55	64	47	64	0,001
	Group – 2	51	55	53	58	50	60	
Weight, kg	Group – 1	37	97	88	104	85	118	0,418
	Group – 2	51	97	80	105	68	144	
Height, m	Group – 1	37	1,8	1,8	1,9	1,7	1,9	<0,001
	Group – 2	51	1,74	1,7	1,8	1,6	1,9	
BMI	Group – 1	37	29,22	27,16	31,05	23,55	35,15	0,432
	Group – 2	51	29,94	26,12	35,06	23,96	45,2	

Table 33. Comparative analysis of general health status in patients with Implants and with natural teeth

- All patients from Group 1 suffer from arterial hypertension, while in Group 2, only 3,9% of patients do not suffer from it, confirming the connection between arterial hypertension and peri-implantitis/periodontitis.
- Patients in both groups generally control their hypertension regularly. Patients in Group 1 manage hypertension with a

higher number of medications compared to Group 2, which contrasts with scientific literature, as there is more limited data on patients with peri-implantitis.

- Most patients in Group 1 have had hypertension for >10 years, while in Group 2, it is <5 years. Respectively, longer hypertension duration is managed with more medications.
- In both groups, most patients have angina pectoris, which has been confirmed in the scientific literature for patients with periodontitis.
- The indications for invasive diagnostics in both groups follow the same descending order: angina pectoris, non-ST-elevation acute coronary syndrome, and ST-elevation acute coronary syndrome. Only in Group 2 is there an indication for valve replacement in 3 (5,9%) cases.
- Patients in both groups predominantly do not suffer from diabetes mellitus, which contradicts data from other studies. ($\chi^2 = 0.0262$, $p < 0.871$)

Presented in Table 34.

Ch-cs		**DM**		
Group:	Stat.Test	**No**	**Yes**	**Total**
Group - 1	Observational	27	10	37
	%	73,0 %	27,0 %	100,0 %
Group - 2	Observational	38	13	51
	%	74,5 %	25,5 %	100,0 %
Total	Observational	65	23	88
	%	73,9 %	26,1 %	100,0 %

Table 34. Comperative analysis of Diabetes Mellitus in patients from Group – 1 and Grop – 2

There are more smokers among patients in Group 2, and our study confirms the findings from the literature. ($\chi^2 = 3.6$, $p = 0.058$)

Presented in Table 35.

Ch-cs		Smoking		
Group	**Stat.Test**	**No**	**Yes**	**Total**
Group - 1	Observational	26	11	37
	%	70,3 %	29,7 %	100,0 %
Group – 2	Observational	25	25	50
	%	50,0 %	50,0 %	100,0 %
Total	Observational	51	36	87
	%	58,6 %	41,4 %	100,0 %

Table 35. Comperative analysis of harmful habit of smoking in patients from Group – 1 and Grop – 2

In both groups, an almost identical lipid profile is observed (cholesterol, LDL-C, HDL-C, triglycerides).
Differences are seen in:

- **HDL-C**, which is higher in patients from Group 1,
- while **triglycerides** are higher in patients from Group 2, unlike other studies that report elevated triglycerides in patients with peri-implantitis.
- **CRP values** in Group 2 are slightly higher than in Group 1, but remain within normal limits, although some studies report the opposite (90).
- **Troponin I (TnI)** is identical in both groups.
- **Creatinine** is higher in Group 1, though still within the normal range, despite literature stating it is slightly elevated in patients with periodontitis.
- **eGFR values** are higher in Group 2.

Both groups show early-stage kidney disease.

Presented in Table 36.

Indicator	Group	N	Me	IQR		Min	Max	p Mann-Whitney U test)
				Q1	Q3			
Total cholesterol	Group-1	37	4,45	2,96	4,5	2,76	6,6	0,13
	Group-2	51	4,4	3,735	5,39	2,72	9,55	
LDL-C, mmol/L	Group-1	37	2,34	2,48	3,1	0,92	3,84	0,058
	Group-2	51	2,49	2,005	3,405	0,89	6,9	
HDL-C, mmol/L	Group-1	37	2,24	0,73	2,65	0,7	2,65	0,299
	Group-2	51	1,12	0,89	1,3	0,59	2,79	
TnI	Group-1	37	0,2	0,2	0,2	0,2	3,51	0,009
	Group-2	47	0,2	0,2	3,905	0,2	180	
3-glycer., mmol/L	Group-1	37	1,23	1	1,95	0,56	3,34	0,257
	Group-2	51	1,41	1,035	2,5	0,44	17,75	
Creatinine	Group-1	37	85	81	127	78	127	0,063
	Group-2	51	82	74,5	102	50	151	
eGFR	Group-1	37	79,7	52,64	83,2	52,64	97,53	0,021
	Group-2	51	85,9	67,8	98,7	42,8	148,7	

Table 36. Comperative analysis of total cholesterol, LDL – C, HDL – C, TnI, 3 – glycerides, creatinine and eGRF in patients from Group – 1 and Group– 2

The **total microbial count** in Group 2 is higher, confirming the statement that **fewer microorganisms cause peri-implantitis**. (p Mann–Whitney U test = 0,026)

The quantity of **P. gingivalis** and **T. denticola** is slightly higher in Group 1, which is also confirmed by other literature sources (162, 180). (p Mann–Whitney U test = 0,959; p = 0,286)

A. actinomycetemcomitans was isolated only in patients from Group 2, again confirming previous scientific data (86). (p Mann–Whitney U test = 0.026)

Presented in Table 37.

Microorganism	Group	N	ME	IQR		Min	Max	p (Mann-Whitney U-test)
				Q1	Q3			
Porphyromonas gingivalis	Group - 1	37	32000	990	62000	0	5500000	0,959
	Group - 2	51	31000	510	230000	0	2200000	
	Group - 1	37	210000	74000	390000	7900	3900000	0,286

Treponema denticola	Group - 2	51	100 000	155 00	445 000	0	1500 000	
Aggregatibacter Actinomycetem comitans	Group - 1	37	0	0	0	0	0	0,053
	Group - 2	51	0	0	0	0	3000 00	
Total microorganisms /1000000	Group - 1	37	630 0	520	130 00	64	2900 0	0,026
	Group - 2	51	950 0	135 0	895 00	2	$3,5x10^8$	

Table – 37. Comperative analysis of total microorganism count, P.gingivalis, T.denticola and A.actinomycetemcomitans in patients from Group – 1 and Group– 2

In both groups, **generalized, plaque-induced inflammatory diseases** are observed according to the **Ainamo & Bay** and **O'Leary** indices, but more cases within the normal range are seen in Group 1.
Ainamo & Bay ($\chi^2 = 3,99$, $p < 0,136$)
O'Leary ($\chi^2 = 5,78$, $p < 0,016$)

Presented in Tables 38 and 39.

GI - Grade					
Group	**N**	**Norm**	**Localized Inflammation**	**Generalized Inflammation**	**Total**
Group – 1	Count	4	1	32	37
	%	10,8 %	2,7 %	86,5 %	100,0 %
	Count	1	4	46	51

Group – 2	%	2,0 %	7,8 %	90,2 %	100,0 %
Total	Count	5	5	78	88
	%	5,7 %	5,7 %	88,6 %	100,0 %

Table 38. Comperative analysis of the gingival index in patients from Group – 1 and Group– 2

PII - O'Leary-Grade				
Group	**N**	**Норма**	**Плакиндуцирано възпаление**	**Общо**
Group – 1	Count	4	33	37
	%	10,8 %	89,2 %	100,0 %
Group – 2	Count	0	51	51
	%	0,0 %	100,0 %	100,0 %
Total	Count	4	84	88
	%	4,5 %	95,5 %	100,0 %

Table 39. Comperative analysis of the plaque index in patients from Group – 1 and Group– 2

SYNTAX Score I is within the normal range in both groups, but slightly higher in Group 2 by 3%. p (Mann–Whitney U test) = 0.182

Presented in Table 40.

Indicator	**Group**	**N**	**Me**	**IQR**		**Min**	**Max**	p (Mann-Whitney U test)
				Q1	**Q3**			

SYNTAX score I	Group - 1	37	7%	0 %	33,50 %	0%	33,50 %	0,182
	Group - 2	51	10 %	0 %	21,50 %	0%	53,50 %	

Table 40. Comparative analysis of SYNTAX score I in patients from Group – 1 u Group – 2

The **median degree of RCx stenosis** is 80% (0; 100) in Group 1.
In Group 2, the median degree of RCx stenosis is 20% (0; 57.5). p (Mann–Whitney U test) = 0,006

The second most affected artery in Group 1 is the **RCA**, with a median stenosis of 75% (0; 100).
In Group 2, RCA shows a median stenosis of 20% (0; 80). p (Mann–Whitney U test) = 0,025

The third most affected artery in Group 1 is the **LAD**, with a median stenosis of 20% (0; 90).
In Group 2, LAD has a median stenosis of 40% (0; 80).
p (Mann–Whitney U test) = 0,638

In Group 1, **no LM stenosis** was observed, whereas in Group 2, **a maximum of 60% LM stenosis** was recorded.
p (Mann–Whitney U test) = 0,085

Regarding the **status of the coronary arteries**, neither group shows widespread LM involvement. The **right coronary arteries are significantly more affected in Group 1 patients**:

- RCx: 80% (Group 1) vs. 20% (Group 2)
- RCA: 75% (Group 1) vs. 20% (Group 2)
- LAD is **twice as affected in Group 2**.

Presented in Table 41.

Coronary Artery	Group	N	Me	IQR		Min	Max	p (Mann-Whitney U test)
				Q1	Q3			
LM, %	Group -1	37	0	0	0	0	0	0,085
	Group -2	51	0	0	0	0	60	
LAD, %	Group -1	37	20	0	90	0	90	0,638
	Group -2	51	40	0	80	0	100	
RCx, %	Γ Group -1	37	80	0	100	0	100	0,006
	Group -2	50	20	0	57,5	0	100	
RCA, %	Group -1	37	75	0	100	0	100	0,025
	Group -2	51	20	0	80	0	100	

Table 41. Comparative analysis of coronary pathology in patients from Group – 1 u Group – 2

Even though the **total microbial count is lower** in Group 1, the **slightly higher presence of *P. gingivalis* and *T. denticola***is associated with more severe changes in the **right coronary arteries**.

Both groups exhibit **good lipid control** through the use of **statins** and **fibrates**.
Only patients from Group 2 take **fibrates**, which is supported by literature.

Statins: $\chi^2 = 4.0$, $p = 0.046$
Fibrate: $\chi^2 = 1.48$, $p = 0.223$

Presented in Tables 42 and 43.

Ch-cs		Statins		
Group	**Stat.Test**	**No**	**Yes**	**Total**
Group - 1	count	9	28	37
	%	24,3 %	75,7 %	100,0 %
Group - 2	count	23	28	51
	%	45,1 %	54,9 %	100,0 %
Total	count	32	56	88
	%	36,4 %	63,6 %	100,0 %

Table 42. Comparative analysis of statine use pathology in patients from Group – 1 u Group – 2

Ch-cs		Fibrate		
Group	**Stat.test**	**No**	**Yes**	**Total**
Group - 1	брой	37	0	37
	%	100,0 %	0,0 %	100,0 %
Group - 2	брой	49	2	51
	%	96,1 %	3,9 %	100,0 %
Total	брой	86	2	88
	%	97,7 %	2,3 %	100,0 %

Table 43. Comparative analysis of fibrate use pathology in patients from Group – 1 u Group – 2

When comparing **Group 1 and Group 2** by the criteria:

- **Probing depth > 3 mm** and
- **Presence of bleeding on probing**,

the following was found:

- In **Group 1**, there were 15 (40,5%) normal cases ($\chi^2 = 1,32$, $p = 0,25$)
- In **Group 2**, only 3 (5,88%) were normal ($\chi^2 = 39,7$, $p < 0,001$)
- Respectively, there were 22 (59,5%) cases with pathology in Group 1 ($\chi^2 = 1,32$, $p = 0,25$)
- and 48 (94,12%) pathological cases in Group 2 ($\chi^2 = 39,7$, $p < 0,001$)

Presented in Table 44.

Health/Pathology in Group -2	**Number**	**Proportion**
Norm	3	0,0588
Pathology	48	0,9412
Health/Pathology in Group - 1	**Number**	**Proportion**
Norm	15	0,405
Pathology	22	0,595

Table 44. Comparative analysis of health/ pathology in patients from Group – 1 u Group – 2

Probing depth median values were measured:

- In **Group 1**: 3.17 mm (2,5; 4,33)

- In **Group 2**: 4.5 mm (3,33; 5,58)
  p (Mann–Whitney U test) < 0,001

Presented in Table 45.

Ch-cs	**Group**	**N**	**Me**	**IQR**		**Min**	**Max**	p (Mann-Whitney U test)
				Q1	**Q3**			
Mean probing depth (mm)	Group-1	37	3,17	2,5	4,33	1,83	4,33	< 0,001
	Group -2	51	4,5	3,33	5,58	2,33	11,17	

Table 45 Comparative analysis of mean probing depth values in patients from Group – 1 u Group – 2

4. Conclusions

1. The most common clinical profile among patients with implants included in the study was: arterial hypertension (AH) with a duration of over 10 years, regularly treated with three medications; statin therapy; normal lipid profile; early-stage renal disease; and absence of diabetes or harmful habits (e.g., smoking).
2. Patients in the control group (with natural dentition) were in better general health compared to those with implants – a smaller proportion suffered from AH, which was of shorter duration and required fewer medications for control.
3. The most prevalent cardiovascular condition among the studied patients was angina pectoris.
4. Patients with coronary artery disease frequently developed peri-mucositis and peri-implantitis. As probing depth increased, the microbial composition became more complex – evolving from *T. denticola* dominance to mixed colonization with *P. gingivalis* and *T. denticola*.
5. Among patients with coronary pathology, *T. denticola* was the most prevalent microorganism, followed by moderate levels of *P. gingivalis*. A positive correlation was observed between their presence. In the most affected region – the molar zone – the highest microbial load involved both *P. gingivalis* and *T. denticola*.
6. The presence of diabetes in patients with coronary pathology correlated with higher levels of *P. gingivalis* and *T. denticola*.
7. Smoking in patients with coronary artery disease altered the microbial profile, leading to a higher prevalence of *T. denticola* compared to *P. gingivalis*.

8. In patients with natural teeth (control group), a higher total microbial count and greater presence of *A. actinomycetemcomitans* were detected, while the levels of *P. gingivalis* and *T. denticola* were lower compared to the main (implant) group.
9. The development of peri-mucositis was associated with elevated levels of *T. denticola*, but not *P. gingivalis*. In contrast, in peri-implantitis, *P. gingivalis* played a dominant role.
10. In patients with peri-implantitis, the **Bleeding on Probing Index (Ainamo & Bay)** and the **Plaque Index (O'Leary)**proved highly useful. Their results positively correlated with each other, with the total bacterial count, and with levels of *T. denticola*.
11. SYNTAX Score I values in all studied patients positively correlated with the microbial load of *T. denticola* and *P. gingivalis*.
12. In the control group (natural teeth), higher Plaque Index values, deeper probing depths, and higher SYNTAX Score I values were observed.
13. In all patients, the **right coronary arteries** were the most frequently affected. The severity of involvement was greater in the implant group compared to the control group.

5.Discussion

Dental implantology has become an increasingly integrated part of everyday dental practice. With the rising number of implants placed, there has also been a noticeable increase in complications—most commonly biological in nature, such as **peri-implant mucositis** and **peri-implantitis**, both primarily associated with **periodontal pathogens**.

When inflammatory changes are present, they tend to occur in a generalized pattern and are typically **plaque-induced**. A **positive correlation** was found between the gingival index and the plaque index, both of which showed statistically significant positive associations with the **total bacterial load**.

Periodontopathogens not only cause **local oral complications**, but also affect **multiple systems beyond the oral cavity**. It has been demonstrated that in the presence of peri-implantitis, **coronary artery involvement** occurs—primarily of the **right coronary arteries**—which increases the risk of **myocardial infarction**.

Accordingly, **prevention and control of periodontopathogens** may contribute to reducing the risk of **coronary artery stenosis** and **myocardial infarction**.

Among all tested pathogens, ***Treponema denticola*** was most frequently isolated, followed by ***Porphyromonas gingivalis***. ***Aggregatibacter actinomycetemcomitans (Aa)*** was **not detected in any** of the PCR samples.

- In **peri-implant mucositis**, *T. denticola* was the dominant species.

- In **peri-implantitis** with probing depth (PD) of 4–5 mm, *P. gingivalis* was more prevalent.
- In peri-implantitis with **PD >5 mm**, both pathogens were present in significant quantities.

A **high microbial load of *T. denticola*** was confirmed with **strong statistical significance**, while *P. gingivalis* showed a **moderate** level of colonization. The **molar region** was the most commonly affected site in both study groups.

In **smoking patients**, *T. denticola* was isolated in higher quantities compared to non-smokers.

Patients with implants showed **lower probing depths**, **lower total microbial counts**, but **higher isolation rates** of *T. denticola* and *P. gingivalis*, and no presence of *Aa*. They also had **lower gingival and plaque index values**, a **higher proportion of non-smokers**, and **greater coronary artery stenosis**.

Importantly, even in patients with **otherwise good general health** (with only arterial hypertension as a comorbidity), **coronary artery involvement** was observed in the presence of **periodontal pathogens**.

Interestingly, although patients without implants had **higher total microbial counts**, the **implant group** exhibited **more significant coronary artery involvement**.

The majority of patients in both groups had **angina pectoris**, controlled hypertension and diabetes, and were on **statin therapy**. No abnormal values were observed for SYNTAX Score I.

- A **strong statistically significant correlation** was found between **SYNTAX Score I** and *T. denticola* levels.
- A **moderate correlation** was found between SYNTAX Score I and *P. gingivalis* levels.

Lipid profile values (cholesterol, LDL-C, triglycerides) were within normal ranges. Only **HDL-C** showed slightly elevated values.

Early-stage renal disease was detected in both patient

groups.

As for **coronary anatomy**, **no involvement** of the **left main coronary artery (LM)** was observed. However, the **right coronary arteries** were significantly more affected in the implant group:

- **RCx** involvement: 80% in group 1 (implants), 20% in group 2 (natural teeth)
- **RCA** involvement: 75% in group 1, 20% in group 2
- **LAD** was more frequently affected in patients with **natural teeth and periodontitis**, with nearly **twice the involvement** compared to the implant group.

6. Contributions

Original Contributions

1. For the first time, a correlation has been established between specific **microorganisms isolated from peri-implant tissues** and **SYNTAX Score I**, indicating a potential link between local oral pathogens and the severity of coronary artery disease.

2. This study is the first to compare the **general health status** and the **condition of peri-implant/periodontal tissues**between patients **with and without dental implants**, providing a clinical framework for evaluating systemic and oral health interactions.

3. A novel association has been identified between **peri-implantitis** and **early-stage chronic kidney disease**, suggesting that peri-implant inflammation may be part of a broader systemic inflammatory profile.

4. For the first time, it was demonstrated that patients with peri-implantitis exhibit **greater involvement of the right coronary arteries** (RCx and RCA), and **milder involvement of the left anterior descending artery (LAD)**. The **RCx** artery was found to be the **most severely obstructed vessel** among all coronary branches studied.

Original Contributions for Bulgaria

1. For the first time, the pathology of the coronary arteries has been investigated in patients with peri-implantitis

Confirmatory Contributions

1. We confirmed the association between **peri-implantitis** and **cardiovascular disease (CVD)**.

2. We confirmed that **Treponema denticola** and **Porphyromonas gingivalis** are isolated in patients with **periodontitis** and **peri-implantitis**, with *T. denticola* being more frequently found in peri-implantitis cases.

3. We confirmed that **Aggregatibacter actinomycetemcomitans** is detected in the **lowest quantities overall**, but more frequently in patients with **periodontitis**.
4. We confirmed that **smoking does not influence** the **number of implants affected by peri-implant mucositis or peri-implantitis**.

5. We confirmed that **implants harbor a lower total microbial load** compared to **natural teeth**.

6. We confirmed that **T. denticola** is isolated in **higher amounts** in cases of **peri-implant mucositis**.

7. Publications Related to the Dissertation

1. Nyagolova A, Slavova V, Angelova R, Hristova R, Tonkova D, Tsoneva Z, Bakhova A, Peev S, Georgiev S. Periodontitis in Patients Undergoing Coronary Angiography: A Cross-Sectional Study. Cureus. 2024 Dec 8;16(12):e75320. doi: 10.7759/cureus.75320. PMID: 39776740; PMCID: PMC11706217.
2. Slavova, Velislava, Stefan Peev, Atanaska Nyagolova, & Zlatina Tsoneva. "Peri-implantitis." *Scripta Scientifica Medicinae Dentalis* [Online], 11.1 (2025): 18-23. Web. 15 Jul. 2025
3. Slavova V, Nyagolova A (June 11, 2025) Comparative Severity of Coronary Artery Disease in Patients With Peri-Implantitis Versus Periodontitis: A Prospective Observational Study. Cureus 17(6): e85794. doi:10.7759/cureus.85794