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Clinical and Microbial Assessment of the Effect of Two Different Abutment Materials in Implant Supported Mandibular Overdentures A Split-Mouth Study

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Abstract:Purpose: The purpose of this study was to evaluate the impact of titanium and zirconia abutments on the health of preimplant tissue. **Methods:** Twenty completely edentulous patients have been selected from the outpatient clinic in the removable prosthodontic department, faculty of dental medicine for girls, Al-Azhar University. A complete maxillary denture and an implant supported mandibular overdenture were constructed. Six and nine months after denture placement, clinical evaluation (plaque index and gingival index) and microbiological assessment (Candida albicans colonization) of the implant have been carried out. **Results:** this study showed the titanium abutment had higher significance difference in plaque index, gingival index and Candida colonization than zirconia abutment. **Conclusion:** The use of zirconia abutments had a significant benefit over titanium abutments in maintaining the health of the soft tissue around implants in mandibular implant-supported overdentures, within the limitations of the follow-up time

Introduction

Edentulism is a critical public health concern and represents the endpoint of long-term dental illness. When treating mandibular edentulism, dental implants provide benefits over traditional dentures by supporting the preservation of alveolar bone and offering significant improvements in prosthesis functions and comfort [(1)].

It was reported that with just two mandibular implants, implant-supported overdentures provide good outcomes [(2)]. Furthermore, it has become accepted that two implant-supported overdenture treatments, compared to traditional denture treatment, represent the standard treatment option for an edentulous mandibular ridge [(3)].

The design characteristics of the prosthetic abutment for implants are thought to be an important element that might affect soft tissue integration and early bone remodeling. [4]. It has been shown that the loss of crestal bone that occurs in the peri-implant bone supporting two-piece implants following abutment placement and prosthesis delivery in patients who are partly or fully edentulous [5].

For many years, titanium (Ti) has been the biomaterial of choice for dental implant abutments because of its favorable, persistent, and well-established response to functional loading on both the hard and soft tissues in the oral environment. Its mechanical strength, corrosion resistance, and biocompatibility are all advantages [6].

Nowadays, zirconia (ZrO2) and alumina are two high-strength ceramics that are often utilized as permucosal implant abutments. Implant abutments made of zirconia combine exceptional durability with aesthetics [7]. This material has better optical and mechanical qualities. Its transformation-toughening capabilities (from tetragonal to monoclinic phase) against flaws and the way it resists fractures under stress have also been shown [8].

The disease of peri implants soft tissues, such as peri-implant implantitis and peri-implant mucositis, can be brought on by microbial adhesion and attachment surrounding dental implants. The condition known as peri-implantitis may result in bone resorption and ultimately implant loss [9]. Candida species are regarded as one of the major etiological and predisposing factors for denture stomatitis. Despite the various kinds of Candida, the most prevalent type found in the oral cavity is Candida albicans. both in the commensal condition and in cases of oral candidosis[10].

The primary causative reasons for crestal bone loss surrounding implants are bacterial infection and plaque accumulation on the implant surface. When an apical plaque mass spreads, clinical and radiological signs of tissue loss appear [11]. According to some research, the gingivitis, which is a condition caused by plaque in the soft tissue around implants, may result in more significant complications than minor swelling around teeth with periodontal ligaments in natural teeth [12].

Fibroblastic cells' adhesion, development, and colonization are critical for the development of a stable and healthy mucosal seal that shields the underlying tissues from the intraoral environment and the harmful effects of microorganisms. Surface characteristics of the abutment, such as surface topography, surface-free energy, and biocompatibility, are important contributing variables [13].

Thus, the purpose of this in vivo study is to compare and assess the effects of zirconia and titanium as implant abutments on the peri implant soft tissues and also show their efficacy on candida albicans inhibition of colonization.

Material and methods:

Patients' criteria for selection:

Twenty male patients were chosen from the removable prosthodontic department clinic at the College of Dental Medicine for Girls, Al-Azhar University. They ranged in age from 55 to 65 and had fully edentulous jaws with sufficient bone in the mandible's anterior and premolar areas to permit implant implantation without the need for bone augmentation. Both the viscosity and flow of their saliva were within normal ranges. They also had a Angel Class I ridge relationship with sufficient space between the arches, no history of abnormal habits, or temporomandibular joint disorders. All surgical and prosthetic procedures were explained to each patient and carried out with the approval of the Al-Azhar University's Dental Medicine Faculty, highlighting the advantages, the risk factors, and the available options for implant treatment.

Each patient signed a voluntary consent form and acknowledged that they understood the trial's guidelines. Individuals who smoked or had used antifungal, antibiotic, or depressive drugs in the six months before to the study's beginning were excluded from participation.

Radiographic and clinical assessment:

Radiographic and clinical assessments were performed. A radiographic template was created for every patient. A cone beam radiograph (PlanmecaParomax 3D, Finland). was used to determine whether bone

height and buccolingual width were available for implant insertion. Furthermore, the bone's quality was assessed, particularly where possible implant sites were concerned. The canine regions were the suggested locations for the implants (bilaterally). The radiographic template converted into a surgical template. Two tapered, self-tapping endosteal implants (Dentium, Super Line II, Korea) measuring 3.6 mm in diameter and 12 mm in length were inserted into each patient at the mandibular canine region.

Surgical procedures:

The lingual and inferior alveolar nerves were blocked bilaterally. In order to restore the original position, The surgical stent was carefully placed on the underlying mucosa and placed across the mandibular ridge. Using a tissue puncher, a circular tissue punch was made to reveal the implant location. Using a hand piece and sharp drills with internal irrigation, a low speed, high torque surgical motor system was used for the drilling process. The osteotomy was guided by the surgical stent and the parallel rod to guarantee that both implants are angled and directed correctly (Fig. 1). Following the completion of the osteotomy sites, each implant was then secured to the bone, and tension was applied with a ratchet until the implant's top flushed with the surface of the crestal bone. The covering screws were placed and fastened over the implant fixings following the implantation of each implant.

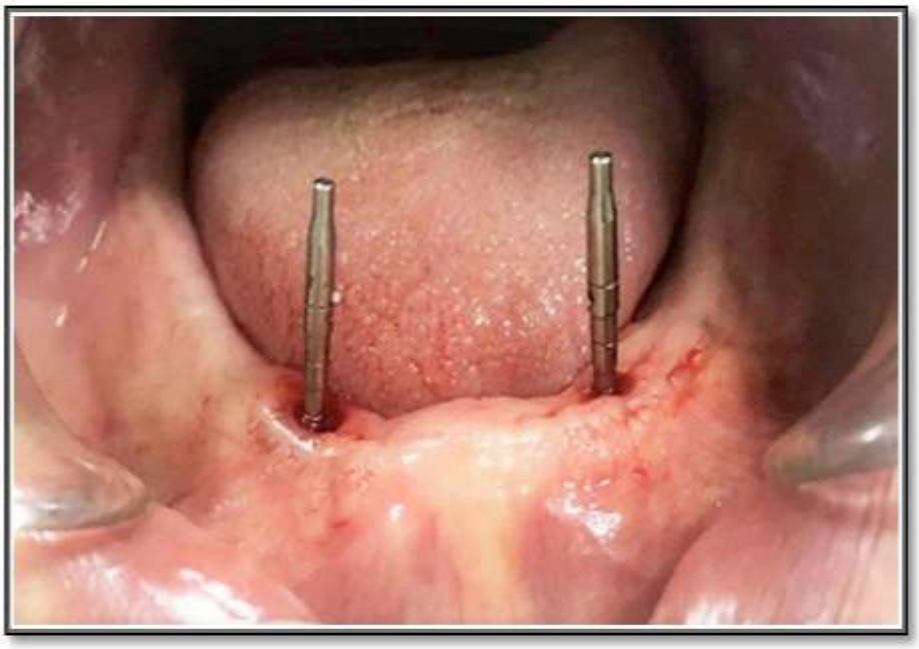

Figure (1): Paralleling rods were inserted into the osteotomy site.

Preparation of the abutments:

For left side, titanium abutment was reduced by 3.2 mm platform diameter, 3 mm length, and 0.5 chamfer finishing line. They were finished and polished for 3 minutes with silicone polisher braso-soft metal polishing brush and polishing paste. Cover screws of the left implant was unscrewed in anti-clockwise direction and titanium abutment was screwed in place using screw driver (maximum 15 Ncm) and checked for proper fit in the implant.

For the right side, titanium base was reduced by a profile bur that is made of tungsten carbide to 2 mm length, platform diameter of 2.2 mm and a finishing line with a 0.5 chamfer. Titanium base there was finished and polished for 3 minutes with silicone polisher, abrazo-soft metal polishing brush and polishing paste. Cover screw of the right implant was unscrewed in anti-clockwise direction and titanium base was screwed in place using screw driver (maximum 15 Ncm) and checked for proper fit in the implant.

Construction of zirconia abutments:

Scanning of mandibular cast and Ti base: The mandibular cast and Ti base abutment were properly inspected for any voids or excess stone material before scanning to ensure accurate scanning. Then sprayed with scanning spray to avoid highlights from cast surface and ensure an accurate scanning.

The mandibular cast was scanned by optical 3D scanner, followed by scanning of Ti base separately producing 3D image of scanned mandibular cast and Ti base on the screen. The scanned abutment was properly inspected separately regarding angulation and position of seated implants. The data was collected with a digital desktop scanner and was checked for extreme accuracy.

Abutment designing was made using software, a virtual image of Ti base appeared on the screen to start the designing step. The parameter values required for designing zirconia abutment (thickness and cementation gab) were selected. Finish line of Ti base was traced to check the thickness, design the margin of the designed zirconia abutment and determine the path of insertion. Abutment thickness was selected to be at 1mm, occlusal surface thickness was kept constant for the abutment at 1.5 mm. An internal gap to provide space for cement was kept constant at 50 microns to stimulate clinical situation.

A milling machine received the computer numeric control (CNC) data and was linked to the CAD system to mill zirconia abutment from partially-sintered zirconia blocks. After complete milling, zirconia abutments were supported on their occlusal surface on the sintering tray which was filled with sintering beads and then sintered in the HTF furnace (High –Temperature Furance with program control unit). Zirconia abutment was supported over a piece of thermal cotton and the Cerabien ZR glazing material was applied over Zr abutment, then inserted on the tray of the glazing furnace for glazing cycle according to the manufacturer instructions.

Finally, zirconia abutment was polished using a special zirconium polishing paste. Zirconia abutment was thoroughly cleaned with ethanol in an ultrasonic bath and air dried. The fit of zirconia abutment to the Ti base was evaluated intraoral, when it was ensured to be accurate, cementation to Ti base was performed using self-adhesive resin cement.

Complete denture construction:

By using an irreversible hydrocolloid impression media, primary impressions were made. (Cavex CA37, Holland). The final impression was made using silicone impression material (poly-C-silicone, thixoflex M, medium, Zhermack, Italy) following border molding using Putty-C-Silicone. After being cleaned, the imprints were boxed and filled with dental stones (Dental Stone is a Spanish company that produces hard stones). Using the maxillary face bow, the maxillary cast was fixed to the articulator. (Hanau model H articulator and face bow, Teledyne Dental, Hanau Division Buffalo, NY, USA), then the patient's centric jaw relation record was used to place the mandibular cast. which was obtained at the prescribed vertical dimension of the maxillary cast. After that artificial teeth made of cross-linked acrylic resin (Acrostone Manufacturing Import, Egypt) were positioned in a balanced occlusion, the patient's denture was checked, and it was waxed.

Heat-cured acrylic resin was used in the processing of the mandibular and maxillary dentures. (Acrostone Manufacturing, Egypt, licensed by WHW, England) in accordance with standard processing procedures. Normal procedures for packaging, curing, deflasking, finishing, and polishing were also followed. Finished dentures were delivered to the patients and examined for proper retention, extension, stability and fine adjustment of occlusion was carried out.

A. Clinical evaluation:

Plaque index outcomes:

A plastic periodontal probe (Kerr Corporation, USA) was used to measure the plaque index in accordance with Modified Plaque Index scores [5] by running it all around each implant abutment's borders. The scores on the modified plaque index are:

Score zero: There was no plaque in sight. Score (1): Plaque can only be found by running a probe over the implant's edge. Score (2) Plaque visible to the unaided eye. Score (3) Abundant of soft material.

To calculate the PI for each abutment on both sides, the scores of the four regions were added up and divided by four.

Gingival index outcomes:

Gingival index according to (LoeH&Silness J, 1963) was developed to evaluate gingival health and document qualitative changes in gingival tissues. It uses a 0–3 scale to grade the marginal and inter-proximal tissues independently.

-Score0=Normal gingival.
-Score1=Mild inflammation, slight change in color, slight edema. No bleeding on probing.
-Score2=Moderate inflammation, redness, glazing, edema, bleeding on probing.
-Score3=Sever inflammation, marked redness, edema, ulceration, Tendency to spontaneous bleeding.

Gingivitis's severity for both abutments has scores on every surface. Four gingival scoring units, which are the distal facial papilla, the facial papilla, the mesial facial papilla, and the whole lingual gingival margin, are applied to the tissues surrounding each abutment. The bleeding potential was assessed by probing gently along the wall of soft tissue of the gingival sulcus (Fig. 2). To calculate the GI for each abutment on both sides, the scores of the four regions were added up and divided by four. These clinical evaluations were done at the time of denture insertion then at six and nine months later.

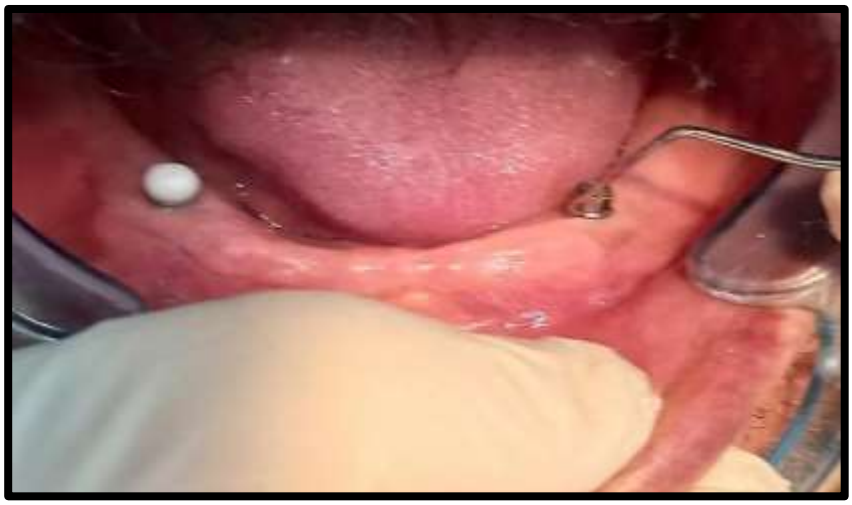

Figure (2): Evaluation of gingival index around titanium and zirconia abutments.

B. Microbiological evaluation:

Samples were collected from nearby areas of the implant's abutments using disposable gamma-sterilized swabs. Before the denture was placed, as well as two, four, and six months later, the samples were taken. The participants were told not to remove their dentures four hours before to the sample and to continue with their regular dental hygiene routines.

Following that, Sabouraud glucose agar plates were used to cultivate mucosal swab samples and cultivated for 24 hours at 37°C. The bacteria. By subculturing each isolated Candida yeast on Chrom agar, the yeasts

were initially numbered and identified. Candida, then obtaining hyphae/pseudo-hyphae and chlamydospore development by the germ tube test.

Also, the amount of candida colonies (colony units of formation for each sample, or CFU/sample) that appeared within the Petri dish was counted. After that, CFU/mL was calculated using that value (CFU/mL is calculated using log 10 CFU/ml, which is the total number of colonies found on the plate plus the saline dilution's inverse quantity divided by the culture plate's volume).

For groups I and II, the mean difference in Candida albicans counts before denture placement, six months later, and nine months later was computed, tabulated, and statistically analyzed.

Results

Statistical analysis:

Values for the mean and standard deviation (SD) were used to show numerical data. They were examined for normality by examining the distribution of the data and using Kolmogorov-Smirnov and Shapiro-Wilk tests. All values were normally distributed. Data were analyzed using paired t-test for intergroup comparisons and repeated measures ANOVA followed by Bonferroni post hoc test for intragroup comparisons. The significance level was set at $p \leq 0.05$. Statistical analysis was performed using SPSS version 26.

I- Clinical evaluation: (plaque index and gingival index)

1-Effect of time on plaque index and gingival index within each abutment:

The plaque index and gingival index mean and standard deviation (SD) values for each abutment at different times were displayed in the table.

1- Titanium abutment:

There was a significant difference between values of the plaque index and gingival index for each abutment measured at different intervals respectively ($p<0.001$). The highest values of both parameters were measured after 9 months (2.23±0.51), (2.86±0.38) respectively.

2- Zirconia abutment:

There was a significant difference between values of the plaque index and gingival index for each abutment measured at different intervals ($P<0.001$). The highest values of both parameters were measured after 9 months (1.21±0.42) (1.29±0.49)

Table (1): Mean, Standard deviation (SD) values of plaque index for each abutment at different intervals:

Parameter	Abutment	At base line	After 6 months	After 9 months	P value
Plaque index	Titanium abutment	0.21 ± 0.02^{A}	0.92 ± 0.12^{B}	2.23 ± 0.51^{C}	**<0.001***
	Zirconia abutment	0.34 ± 0.03^{A}	0.52 ± 0.15^{B}	1.21 ± 0.42^{C}	**<0.001***
Gingival index	Titanium abutment	0.14 ± 0.38^{C}	1.57 ± 0.53^{B}	2.86 ± 0.38^{A}	**<0.001***
	Zirconia abutment	0.14 ± 0.38^{B}	0.57 ± 0.53^{AB}	1.29 ± 0.49^{A}	**<0.001***

A statistically significant difference is shown by different superscript letters. within the same horizontal row

*; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

2-Comparisons between both abutments:

The plaque index and gingival index mean and standard deviation (SD) values for group I and II were displayed in the table (2).

At baseline: there was non-significant change in plaque index or gingival index values between zirconia and titanium abutment respectively ($P=0.127$), ($P=1$)

After 6 months: Titanium abutment had a significantly higher plaque index and gingival index values than zirconia abutment ($P<0.001$), ($P=0.025$)

After 9 months: Titanium abutment had a significantly higher plaque index and gingival index values than zirconia abutment (P<0.001), (P=0.008)

Table (2): Mean, Standard deviation (SD) values of plaque index and gingival index respectively for both zirconia and titanium abutments:

Parameter	Interval	Plaque index , gingival index (mean±SD)		P-value
		Titanium abutment	Zirconia abutment	
Plaque index	At base line	0.34±0.03	0.21±0.02	**0.127**
	After 6 months	0.92±0.12	0.52±0.15	**<0.001***
	After 9 months	2.23±0.51	1.21±0.42	**<0.001***
Gingival index	At base line	0.14±0.38	0.14±0.38	**1.000ns**
	After 6 months	1.57±0.53	0.56±0.41	**0.025***
	After 9 months	2.86±0.38	1.29±0.49	**0.008***

* Significant ($p \leq 0.05$) ns; non-significant (p>0.05)

II- <u>Microbiological evaluation:</u>

1- Effect of time on microbiological activity within each abutment:

Mean and Standard deviation (SD) values of the candida albicans count (CFU/ml) for two different intervals were presented in table (3) and fig(3).

For titanium and zirconia abutments, there was significant increase in candida albicans count (CFU/ml) after 9 months respectively (P<0.001), (P=0.042).

Table (3): Mean and Standard deviation (SD) values of candida albicans count (CFU/ml) for two different intervals:

Abutment	Candida albicans count (CFU/ml)(mean±SD)			P-value
	At baseline	After 6 months	After 9 months	
Titanium abutment	22.83 ± 5.46^{A}	190 ± 22.54^{B}	308.33 ± 36.23^{B}	<0.001*
Zirconia abutment	12.83 ± 2.32^{A}	61.28 ± 9.48^{A}	94.83 ± 14.72^{B}	0.042*

*; significant ($p \leq 0.05$) ns; non-significant (p>0.05) Different superscript letters indicate a statistically significant difference within the same horizontal row

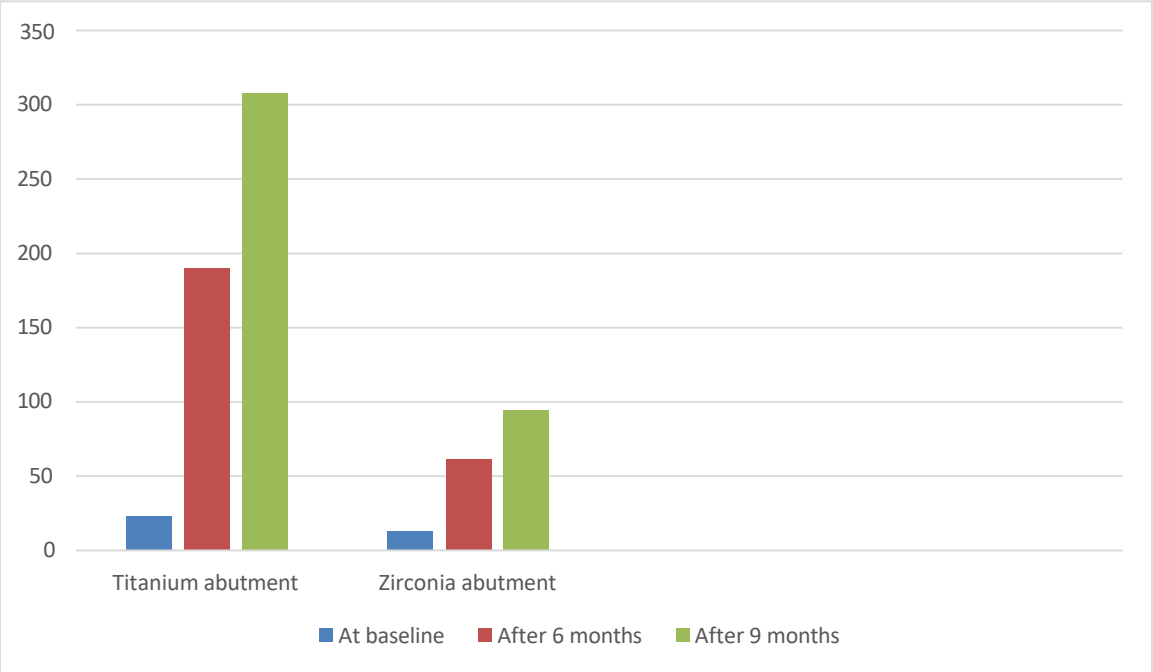

Figure (3): Bar chart showing average Candida albicans count (CFU/ml)for each abutment at different intervals.

2- Comparisons of microbiological activity between both abutments:

Comparison of mean and Standard deviation (SD) values of the candida albicans count (CFU/ml) for different abutments were presented in table (4) and (fig4)

At baseline, there was non- significant change in candida albicans count (CFU/ml) between titanium and zirconia abutments. (P=0.063)

After 6 months, there was a significant change in candida albicans count (CFU/ml) between titanium and zirconia abutments. (P<0.001)

After 9 months, there was a significant change in candida albicans count (CFU/ml) between titanium and zirconia abutments. (P<0.001)

Table (4): Mean and Standard deviation (SD) values of candida albicans count (CFU/ml) for two different abutments:

Interval	**Candida albicans count (CFU/ml)(mean±SD)**		**P-value**
	Titanium abutment	**Zirconia abutment**	
At baseline	22.83±5.46	12.83±2.32	**0.063**
After 6 months	190±22.54	61.28±9.48	**<0.001***
After 9 months	308.33±36.23	94.83±14.72	**<0.001***

* significant ($p \leq 0.05$) ns; non-significant (p>0.05)

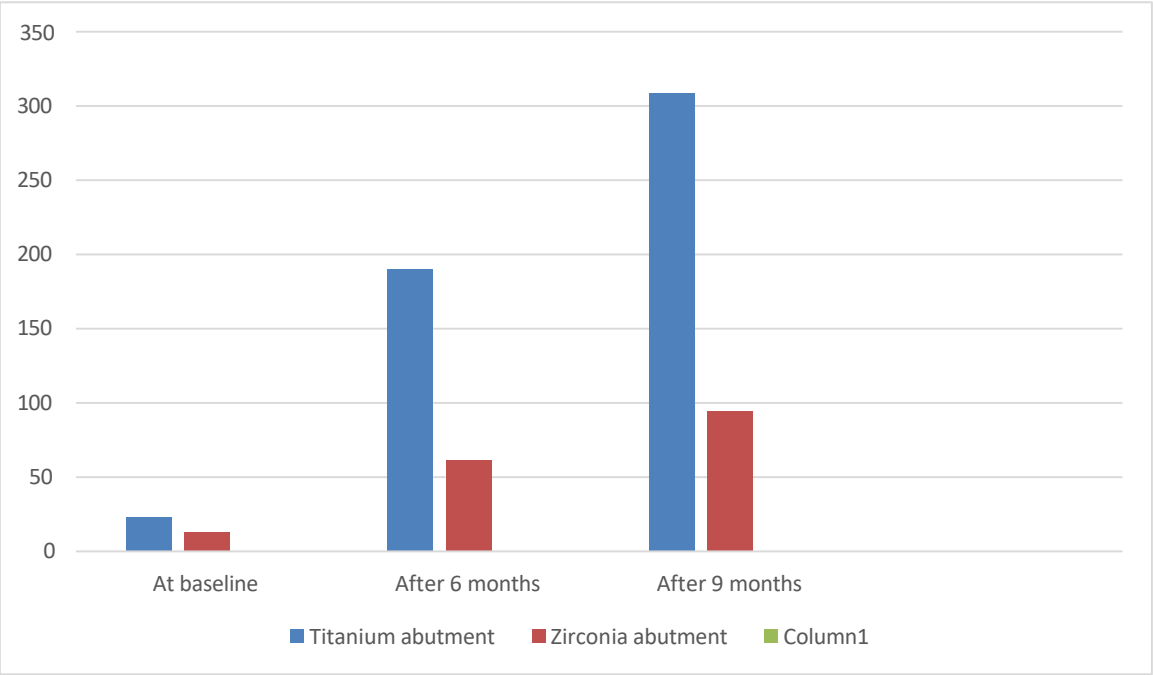

Figure (4): Bar chart showing average Candida albicans count (CFU/ml)for each abutment

Discussion

The purpose of this study was to assess and compare the impact of titanium and zirconia as implant abutments on the soft tissues around implants and also show their efficacy on candida albicans inhibition of colonization.

For the goal of identifying early disease signs and carrying out therapeutic treatments effectively, the peri-implant tissues clinical examination is essential. Reduce the need to treat an active case of peri-implantitis by diagnosing peri-implantitis and peri-implant mucositis as soon as possible, especially in the early stages of the diseases. [15].

Titanium abutments were chosen Because of titanium had unique physical properties. Also, an abundance of research demonstrates titanium abutments' favorable soft tissue response. [16].

Because of their superior mechanical strength, water insolubility, and biocompatibility, zirconia abutments are now recognized as the primary ceramic abutments. Zirconia abutments might additionally prevent bacterial adherence. [17].

In comparison between the effects of titanium and zirconia abutments on peri-implant gingival index and plaque accumulation, titanium abutments had significantly higher values than zirconia abutments at six and nine months. This is in accordance with the study that reported a significantly increased accumulation of plaque on titanium abutments compared to zirconia ones placed in the oral cavity. This is due to the presence of higher levels of bacterial loads around Ti abutment [19].

In addition to that, these results more also in accordance with study explained that since titanium's surface is rough, which is important for microbial adhesion, titanium abutments have a high concentration of microorganisms and biofilm mass; in comparison, zirconia abutments have a free surface, which reduces the likelihood of bacterial adhesion and has a positive effect on soft tissue parameters [19].

In addition, it was reported also that human gingival fibroblasts seem to favor zirconia in general. The highest number of fibroblast and epithelial cells was detected on zirconia surface due to its highly smooth surface [20]

Conclusion:

The use of zirconia abutments had a significant benefit over titanium abutments in maintaining the health of the soft tissue around implants in mandibular implant-supported overdentures, within the limitations of the follow-up time.

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