COMPARATIVE EVALUATION OF FORCE TRANSMISSION AND WEAR RESISTANCE BETWEEN TITANIUM AND ZIRCONIA ABUTMENT AT IMPLANT ABUTMENT INTERFACE AFTER CYCLIC LOADING - AN INVITRO STUDY

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – I

PROSTHODONTICS AND CROWN AND BRIDGE

MAY -2019

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI – 600032

2016 – 2019

CERTIFICATE - I

This is to certify that the dissertation titled **"COMPARATIVE EVALUATION OF FORCE TRANSMISSION AND WEAR RESISTANCE BETWEEN TITANIUM AND ZIRCONIA ABUTMENT AT IMPLANT ABUTMENT INTERFACE AFTER CYCLIC LOADING - AN INVITRO STUDY** is a bonafide work done by **Dr. V.S.VAISHNAVI**, Postgraduate student, during the course of the study for the degree of "Master of Dental Surgery" in Department of **PROSTHODONTICS AND CROWN & BRIDGE**, CSI College of Dental Sciences and Research, Madurai during the period of 2016-2019, under our supervision and guidance.

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ETHICAL COMMITTEE

Title of the work : Comparative evaluation of force transmission and wear resistance between Titanium and Zirconia abutment at implant abutment interface after cyclic loading: An in-vitro study

Principal investigator: Dr.V.S.Vaishnavi (PG student) **CSICDSR/IEC/27-1E/2016**

Department: Department of Prosthodontics

The request for an approval from the Institutional Ethical Committee (IEC) for the above mentioned study, submitted by the Principal investigator is considered in the IEC meeting held on 08.09.2016 at CSI College of Dental Sciences and Research, Madurai. The members of the committee are unanimously pleased to approve the proposed work mentioned above and is '**Advised to proceed with the study'**

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8. You should not claim funds from the institution while doing the work or on completion.
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DECLARATION BY THE CANDIDATE

TITLE OF DISSERTATION	COMPARATIVE EVALUATION OF FORCE TRANSMISSION AND WEAR RESISTANCE BETWEEN TITANIUM AND ZIRCONIA ABUTMENT AT IMPLANT ABUTMENT INTERFACE AFTER CYCLIC LOADING - AN INVITRO STUDY.
PLACE OF STUDY	CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH
DURATION OF COURSE	3 YEARS
NAME OF THE GUIDE	Dr. R.LAMBODHARAN M.D.S
HEAD OF THE DEPARTMENT	Dr. R.LAMBODHARAN M.D.S

I hereby declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Principal, CSI College of Dental Sciences and Research, Madurai. In addition, I declare that no part of this work will be published either in print or electronic without the guide who has been actively involved in this dissertation. The author has the rights reserved for publishing the work solely with prior permission of the Principal, CSI College of Dental Sciences and Research, Madurai.

Head of the Department **Guide** **Signature of the candidate**

CERTIFICATE – II

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This is to certify that this dissertation work titled **" COMPARATIVE EVALUATION OF FORCE TRANSMISSION AND WEAR RESISTANCE BETWEEN TITANIUM AND ZIRCONIA ABUTMENT AT IMPLANT ABUTMENT INTERFACE AFTER CYCLIC LOADING- AN INVITRO STUDY "** of the candidate **Dr. V.S.VAISHNAVI** for the award of **MASTER OF DENTAL SURGERY** in the **BRANCH I – PROSTHODONTICS AND CROWN AND BRIDGE**.

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LIST OF GRAPHS

MK BEST CALIBRATION SERVICES
एमके बेस्ट केलिब्रेशन सर्विसेस्

No. 27, F-2, 1st Floor, 2nd Street, Varalakshmi Nagar, Maduravoyal,
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Ph.: 044 - 6548 0211, Cell : 93802 66480 / 86958 18108 / 90032 77250
E-mail: mkbestcalibration@gmail.com, www.mkbestcalibrationservices.com

CERTIFICATE OF CALIBRATION

Certificate No	: MKB-1954-001	Date of Issue	: 14.09.2017
Date of Calibration	: 14.09.2017	Recom.Due Date	: 13.09.2018

Customer Details :

M/s: **Dr. VAISHNAVI V.S.,**
POST GRADUATE,
DEPARTMENT OF PROSTHODONTICS,
CSICDSR, MADURAI.

SRF.No	: MKB-16-17-1954
Date of Receipt	: 14.09.2017
Condition of UUC Received	: Satisfactory

Details Of Unit Under Calibration :

Description	: Helical Spring	Identification No	: —
Length	: 50 mm	Range	: —
Outer Dia	: 15 mm	Resolution	: —

NABL TRACEABILITY DETAILS

S.No	Description	Id.No/Sl. No	Traceability	Certificate No	Validity
01	Loadcell&indicator	MK/CAL-106	National Standards	ICPL/17/CS00730/M-03	12-Aug-18

Environmental Details : Temperature: 20.3 °C **Relative Humidity:** 45 %

CALIBRATION RESULT

Set Load (N)	Indicator Reading (N)
200	200

Remarks:

1.The Above Material Can withstand Load upto 200N (1 Kg = 10N)

Calibrated by

M.Sasikumar
Calibration Engineer

MK BEST CALIBRATION SERVICES CHENNAI

Authorised Signatory

K.Sudhagar
Technical Manager

DHAYA CALIBRATION
Engineering Instrument

No.78, 1st Floor, TPK Road,
PR Complex, Andalpuram,
Madurai -625003

Mobile No: 9842143016, Off: 04524378016
Email: nallasivamdaya@gmail.com
Web site: www.dhayacalibration.com

CERTIFICATE OF CALIBRATION

Certificate No : DCEI/2260/2017
Name of the Customer : **Miss.Dr.V.S.VAISHNAVI,**
CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH
No.129, East Veli Street,
Madurai-625001

Details of Instrument:

Description	:	TORQUE WRENCH
Make	:	MIS, MODEL: MT-RTO7O, SL NO.W16008852
Range	:	0 -75 Ncm
Identification Number	:	TW - 01
Date of Calibration	:	20.12.2017
Next Calibration	:	19.12.2018

Reference Equipment Traceability:

The above instrument is calibrated with our Master pressure gauge which is traceable to National standards by, NPL, Delhi, Ministry of Micro Small & Medium Enterprises Testing Center **(Govt of India)** Chennai. Certificate No- **MSME 6016/ 2017-2018,** Date of calibration: **08.03.2018,** Next Due on: **08.03.2019**

Environmental Condition: Temperature: 25° ± 2°C Relative Humidity: 40 - 70 % Result of calibration: Refer page 2

Remarks

Test reading given was the average of 3 measurements.

CALIBRATED BY

M.MUTHU SANTHOSH

DHAYA CALIBRATION ENGINEERING INSTRUMENTS * MADURAI-11 * CALIBRATION DONE

APPROVED BY

Er. A.NALLASIVAM,
(Competent Person & Chartered Engineer)

Mobile No: 9842143016

Off: 04524378016

DHAYA CALIBRATION ENGG INSTRUMENTS

78,1st Floor, PR Complex, Andalupuram
Madurai – 625003

CALIBRATION CERTIFICATE

CERTIFICATE NO : DCEI/2860/2017

DATE: 20.10.2018

CALIBRATION RESULTS

SL NO	STANDARED READING	MEASURE READING	OBSERVED ERROR
1	0.00 Ncm	0.00 Ncm	0.00 Ncm
2	20.00	20.00	0.00
3	25.00	25.00	0.00
4	30.00	30.00	0.00
5	35.00	35.00	0.00
6	40.00	40.00	0.00
7	45.00	45.00	0.00
8	50.00	50.00	0.00
9	60.00	60.00	0.00
10	70.00	70.00	0.00

VISUAL INSPECTION : OK

WORKING CONDITION:OK

CALIBRATED BY

The reported results are valid only the condition of the received above instrument/gauge at the time of under the stated condition of the calibration

For Dhaya Calibration Engg Instruments

DHAYA CALIBRATION ENGINEERING INSTRUMENTS
CALIBRATION DONE
MADURAI-11

DHAYA CALIBRATION
Engineering Instrument

No.78, 1st Floor, TPK Road,
PR Complex, Andalpuram,
Madurai -625003

Mobile No: 9842143016, Off: 04524378016
Email: nallasivamdaya@gmail.com
Web site: www.dhayacalibration.com

CERTIFICATE OF CALIBRATION

Certificate No	:	DCEI/2261/2017
Name of the Customer	:	**Miss.Dr.V.S.VAISHNAVI** CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH No.129, East veli Street, Madurai-625001

Details of Instrument:

Description	:	TORQUE WRENCH
Make	:	ALPHA BIO
Range	:	0 -40 NCM
Identification Number	:	TW - 01
Date of Calibration	:	20.12.2017
Next Calibration	:	19.12.2018

Reference Equipment Traceability:

The above instrument is calibrated with our Master pressure gauge which is traceable to National standards by, NPL, Delhi, Ministry of Micro Small & Medium Enterprises Testing Center **(Govt of India)** Chennai. Certificate No- **MSME 5440/ 2017-2018,** Date of calibration: **28.02.2017,** Next Due on: **28.02.2018**

Environmental Condition: Temperature: 25° ± 2°C Relative Humidity: 40 - 70 % Result of calibration: Refer page 2

Remarks

Test reading given was the average of 3 measurements.

CALIBRATED BY
M.MUTHU SANTHOSH

DHAYA CALIBRATION ENGINEERING INSTRUMENTS MADURAI-11 CALIBRATION DONE

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Madurai – 625003

CALIBRATION CERTIFICATE

CERTIFICATE NO : DCEI/2261/2017 DATE: 20.12.2017

CALIBRATION RESULTS

SL NO	STANDARED READING	MEASURE READING	OBSERVED ERROR
1	0.00 NCM	0.00 NCM	0.00 NCM
2	10.00	10.00	0.00
3	20.00	20.00	0.00
4	30.00	30.00	0.00
5	40.00	40.00	0.00

VISUAL INSPECTION : OK WORKING CONDITION:OK

CALIBRATED BY

The reported results are valid only the condition of the received above instrument/gauge at the time of under the stated condition of the calibration

For Dhaya Calibration Engg Instruments

DHAYA CALIBRATION ENGINEERING INSTRUMENTS * MADURAI-11 * CALIBRATION DONE

Introduction

INTRODUCTION

The interest in dental implants has grown significantly with the introduction of "OSSEOINTEGRATION" concept by PI Branemark in the year 1983. There is a marked rise in patient's demands as regard to quality of life and a good appearance makes it mandatory for the prosthodontist to provide functionally, aesthetically and physiologically optimal dental prosthesis. Hence forth people switch to a better option of dental implants as a revolutionary way of replacing missing tooth.

Dental implants have become a successful treatment of choice to replace single missing teeth with the following advantages of success rates above 97% for 10 years, with decreased risk of caries and endodontic complications to adjacent teeth, with improved esthetics and better ability to clean the interproximal spaces of adjacent teeth. With its highest advantage of improved maintenance of bone in the edentulous site, it helps in decreased abutment tooth loss unlike the traditional three-unit partial fixed restorations[14].

A single anterior implant is highly predictable and has a high success rate. For the posterior restorations, the direction of the occlusal forces and functionality of the restoration are of primary importance than aesthetics. Restoring a posterior single implant poses many challenges. It should satisfy the biological, functional and biomechanical parameters which were examined preoperatively.

Current paradigms for treatment success in implant dentistry based not only on true clinical outcomes such as implant survival, intra oral survival and patient satisfaction but also on other clinical outcomes such as rate of mechanical complication, bone levels, dentogingival aesthetics, amount of occlusal force transmission and health of surrounding oral tissues.

The function of Titanium dental implants for replacing teeth in the oral cavity is well documented. Due to high implant survival and success rates, the aesthetic outcome has become focus of interest in aesthetically demanding areas which shows gingival thickness of 2mm or less, the use of standard Titanium abutment may compromise the appearance of tissue colour in the aesthetic zone. This is due to the transmission of blue hues of the metal through the soft tissue by the Titaniumabutment[40]. This subsequently led to the development of more esthetic ceramic abutment material produced in densely sintered alumina. The peri – implant soft tissue acceptance was recorded in human and animal studies. The Titanium and alumina abutments show similar results around the soft tissues. Despite its esthetic success, several clinical studies reported additional fractures with alumina abutments compared to Titanium abutments. Due to this drawback in its mechanical property, all ceramic implant abutments have been introduced in the year 1991 (Cer Adapt, Nobel Bio Care, Gothenberg, Sweden) to satisfy the esthetic demands at the cervical gingival margin. Current popular all ceramic material for fabrication of implant abutment is zirconia. In vitro mechanical flexural strength of Zirconia has been recorded to be 900 to 1200 MPa, which is approximately twice that of alumina. the fracture load of Zirconia was also found to be more than twice that of alumina with high bending strength. The combination of a Zirconia abutment and crown provides better translucency and therefore a better aesthetic outcome of the restoration as compared to a metal abutment.

Zirconia is a polymorph that exists in three phases: Monoclinic (M), Tetragonal (T) and Cubic (C). Unalloyed Zirconia is in the monoclinic form at room temperature and upon heating up to 1170º C. The structure is tetragonal between temperatures 1170 - 2370º C. From 2370º C to its melting point, it exists in the cubic form. The most desirable phase is the tetragonal phase. Several stabilizing oxides such as CaO, MgOCeO2 or Y2O3 help retain the tetragonal structure at room temperature and minimizes the stress induced transformation thereby arresting crack propagation. Due to their optical, mechanical and biological properties, high strength ceramic abutments such as B yttrium– stabilised tetragonal Zirconia polycrystals have been increasingly used. A currently popular material for fabrication of implant abutments is Zirconia (3-yttria stabilized Zirconia polycrystals). 3y-TZP is a white ceramic with physical properties very different from titanium. Zirconia is stronger, harder, and potentially with more abrasive properties than titanium. Commercially pure Titanium (Grade four) has a strength value of 550 MPa, while Zirconia has shown strengths greater than 1000 MPa. Zirconia is five times harder than Titanium using the Knoop hardness scale. Clinical studies showed the suitability of Zirconia abutments in the oral cavity for single tooth replacement in the anterior region[32].

There are multiple implant - abutment interface geometric variations available of which internal and external hex design is very popular. Internal hex connections have the advantage of better shielded abutment screw and long internal wall engagement that creates a stiff, unified body to resist joint micro movement when compared to external hex connection.[63]

The implant - abutment interface is the key determining factor for the implant system to reach clinical success. It is influenced by several factors such as the material of the abutments and precision in fabrication of its components, the preload on retaining theabutment screw, the micro gap, the connection geometry and aging. The Zirconia abutments are of two types.one being the 2-piece Zirconia abutments, in which the Titanium or a Titanium alloy element gets engaged to the dental implant and transmucosal Zirconia element. The other is the 1- piece Zirconia abutments, where the entire abutment is made of zirconia. In both types, a metal abutment screw is used to retain the abutment.

The degree of mechanical integrity at the implant abutments interface is the determining factor for abutment screw loosening which is dependent on implant abutment connection design, implant platform, component fit, abutment screw preload tightening force, screw design, screw length, material properties of screw, static and dynamic loading conditions and direction of loading.The implant platform is normally in the same axis that of the body of the implant. Forces axial to the implant will result in compressive forces at the implant - abutment interface. In off axial forces to the implant results in tensile forces at the implant platform resulting in bending forces.

Despite the success reporting in-vitro studies[43,50,] some issues are not still clear, including the fact that connected Zirconia to Titanium implant subjected to load leading to changes in the connection surfaces, and mastication may involve micro movements in the contacting surfaces of abutment implant interface, causes wear fatigue. It was observed that the strength of the Zirconia abutment decreased after cyclic loading[32]. The very purpose of this invitro study is to evaluate whether cyclic loading affects the strength which is of more concern in the posterior region where the occlusal forces are high. Hence two fibre reinforced epoxy resin blocks (NEMA G-10 ROD) which has approximately the same modulus of elasticity of mandible[56,48,25] was connected to the customized jig. Two internal connection implants (3.75×10mm, MIS Implants) were mounted in fibre reinforced epoxy resin blocks. The implants were placed into the blocks using the classical drilling protocol and torqued to 45 N/cm. Ten Titanium abutments and ten Zirconia abutments were torqued to the implants to 25N/cm. The mounted implants and abutments were placed into a loading jig that affixed to a cyclic loading machine.

The implant – abutment assemblies were cyclically loaded with a force of 200N at frequency of 2Hzfor 1,80,000cycles which simulates 4 months of intra oral condition. The interface surface of the abutments at the abutment collar was examined using scanning election microscope (TESCAN) before and after cyclic loading. The suspended particles if any at the implant - abutment interface was observed by EDAX (Energy Dispersive X ray particle Analysis). In sight of the above considerations,

The aim of this study was to evaluate the wear resistance between the Titanium and Zirconia abutments at the implant - abutment interface after force transmission in axial direction using cyclic loading and the surface characteristic changes using scanning electron microscope and EDAX (Energy Dispersive X -ray Analysis) to analyse the suspended particles.

1. To evaluate the surface of Titanium abutment at the implant - abutment interface using scanning electron microscope pre-cyclic loading under various magnifications.

2. To evaluate the surface of Zirconia abutment at the implant - abutment interface using scanning electron microscope pre-cyclic loading under various magnifications.

3. To evaluate the wear resistance of the Titanium abutment subjected to force transmission at implant - abutment interface after cyclic loading using scanning electron microscope under various magnifications.

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7. Energy dispersive X ray analysis of the Zirconia abutment at implant – abutment interface after cyclic loading.

8.To compare the energy dispersive X ray analysis of the Zirconia and Titanium abutment at the implant-abutment interface after cyclic loading.

8.Energy dispersive X ray analysis in the internal hex of the implant loaded with Zirconia abutment after cyclic loading.

9.Energy dispersive X ray analysis in the internal hex of the implant loaded with Zirconia abutment after cyclic loading.

10. To compare the Energy dispersive X ray analysis in the internal hex of the implant loaded with Zirconia and Titanium abutment after cyclic loading.

Review of Literature

REVIEW OF LITERATURE

Schmidt et al (1970)[52] demonstrated a method for recording tooth contact by electromyographic method. Radio telemetry has been the principal method used in recent years to directly record tooth contact.

Pameijer et al (1970)[44]This is a report on contacts of natural teeth during swallowing as registered by an intraoral telemetry system described in previous studies. Contacts of teeth occurred in centric relation in only 5 of 182 swallows in this study, as compared with 162 contacts in centric occlusion. The 5 tooth contacts in centric relation were part of glides which started in centric occlusion, and the contact in centric occlusion was of longer duration than the fleeting contact in centric relation during swallowing.

Gibbs et al (1981)[3]reported the Occlusal forces during chewing and swallowing as measured by sound transmission. Occlusal forces during chewing were found to be surprisingly high (58.7 pounds, 26.7 kg), during the relatively long 194 ms phase of occlusal contact and low during both the closing phase (18.2 pounds, 8.3 kg) and the opening phase (12.5 pounds, 5.7 kg). Swallowing occurred primarily in the intercuspal position, yielding a force of 66.5 pounds (30.2 kg), which was higher than the chewing forces. Swallowing force persisted for 552 ms at the intercuspal position. The forces produced during swallowing (66.5 pounds; SD, 55 pounds) were greater than those occurring during chewing (58.7 pounds, SD 45.6 pounds). The swallowing force, on the average, was 41% of the subject’ s maximum biting force. The phase of occlusal contact during swallowing was considerably longer and more variable (683 ms; SD, 249 ms) than the phase of occlusal contact during chewing (194 ms; SD, 38 ms). Duration of forces produced during swallowing averaged 522 of the total 683 ms, or about 76% of the occlusal phase. Forces during the phase of occlusal contact during chewing and swallowing are surprisingly high (36.2% and 41%), about 40% of the subject' s maximum biting force.

Dixon et al, (1995)[25] compared the screw loosening, rotation, and deflection among three implant designs. A common problem associated with single tooth implant restorations is abutment screw loosening. Incorporating anti rotational design characteristics into their systems was introduced by the manufacturers. Micro movement and torque levels required to loosen abutment screws for straight and angled antirotational screw-retained abutment/implant combinations from three different manufacturers were examined in this in vitro investigation. To conclude, there were no significant differences between the straight and angled abutments for rotation, deflection, and torque required to loosen the screws.

Prestipino et al, (1996)[47] used the all- ceramic abutment made from an aluminium oxide based ceramic material, for high strength, excellent wear resistance, Bio-compatibility, excellent tooth coloured aesthetics. They concluded that aesthetics, the study of beauty is both extremely subjective and highly personal. In the matter of dental aesthetics, not only must each tooth replacement function well, but also the colour and shape of each one must be individually satisfied.

Darby et al (1996)[21] measured the biological aspects of the soft tissue at Titanium implant interface. The soft tissue seal around a dental implant provides an essential physiological and biological barrier from the external environment.

Hebel et al (1997)[35] Studied the optimal occlusion and aesthetics in implant dentistry by comparing cement- retained and screw retained implant restoration. In this study axial loading of implants were taken into consideration. Many factors interact in a complex manner to produce a load at the bone-implant interface. offset loading is one factor that can be controlled with prosthesis design. Although literature is inconclusive in determining the negative consequences of offset loading on the bone implant interface, bio- mechanical principles show that increasing the stress at the bony interface. Axial loading is preferred for implants and the bone-implant interface and offset load may be harmful.

Winkler Sheldon (2000)[61]calculated the normal swallowing and functional masticating contacts was less than fifteen minutes per waking day in a denture wearer. And the swallowing forces were calculated to be 11.4 pounds on an average**.**

Cibirika et al (2001)[17] examined the potential difference in detorque values of abutment screws after fatigue testing when the dimensions between external implant hexagon and internal abutment hexagonal shape was eliminated. This study concludes that increasing the vertical height, or degree of fit tolerance, between the implant external hexagon and the abutment internal hexagon or eliminating the external hexagon did not produce a significant effect or the detorque value of the abutment screws after 5,000,000 cycles in fatigue testing, or the equivalent of 5 years of mastication for the implants/abutments specimens evaluated.

Gibbs et al (2002)[29] Studied the maximum clenching force of patients with moderate loss of posterior tooth support patients who have lost posterior tooth support may also lose clenching force because of increased loading to the remaining teeth and possibly a loss of muscle strength because clenching forces are reduced to avoid stress to the remaining teeth. IN I study denture wearers even with good ridges could exert only 156 N(351bs) on average compared with healthy adults with complete dentition who produced a mean clenching face of 720N (162165) clenching forces varies considerably, even in healthy adults with a full dentition. In a study of 20 healthy full- dentition adults, maximum clenching force ranged from 244 to 1243N (55 to 2801bs). Therefore, average values may provide a general statistical ratio with the limitation of this study it was estimated that maximum clenching strength was significantly less, 258 N(581bs), P≤ 01. The wide range of clenching strength demonstrated by both the subjects with missing teeth and the subjects with fully dentition indicate that some persons, even some with missing teeth may be able to produce a high clenching force and unexpected high stress with restoration.

Yildirim et al (2003)[63] investigated the in-vivo analysis to quantify the fracture load of implanted – supported Al2O3 and ZrO2 abutments restored with glass ceramic crowns. Higher fracture loads for specimens restored by ZrO2 ceramic abutments were expected because Y2O3 partially- stabilized ZrO2 ceramic displays twice the flexural strength (900 MPa to 1400 MPa) and fracture toughness (7 to 10 MPa m1/2) than Al2O3 ceramic to conclude within limitation both groups of all ceramic abutments withstood an appropriates fracture load (90-370N) for use on Branemark dental implants the fracture loads were 280.1 N ± 103.1 and 737.6 N ± 245.0 for the Al2O3 ceramic abutments and ZrO3 ceramic abutments respectively. ZrO2 ceramic abutments withstood fracture loads more than twice as high as those recorded for ZrO2 ceramic abatements showed a more inhomogeneous fracture pattern.

Broadbeck et al (2003)[12] Discuss the clinical and laboratory features of new ceramic abatements Zi Real Post (Implant Innovations, Inc. Florida). The Zirconia used in the Zi real post in Zirconium Oxide (ZrO2) that is partially stabilized with 3%

yttrium oxide. This Zirconia ceramic is characterised by fine grained microstructures knowns as tetragonal Zirconia polycrystals (TZps) Zirconia has a transformation toughening mechanism in its microstructure that is not found in other ceramics Zirconia is significantly stronger than other ceramics, which should result in fewer post-treatment complications. Zirconia has already been proven clinically as an abutment material in the literature; a 4-year clinical study at the university of Zurich reported no fractures.

The Zi Real Post is made from Zirconia, however the apical portion of Zi Real Post that seats onto the restorative platform of the implant is made of Titanium Zirconia has been used in Europe since the 1980S as bearings in total hip replacement. At present time ceramic abatements and all ceramic crowns are the ideal combination to obtain optimal aesthetics.

When Cer Adapt was introduced in 1991, implantology was confronted for the first time with a ceramo-metal contact at the implant abutment interface. The alumina ceramic was to be in direct contact with the Titanium implant restorative platform. When metal and ceramic are contact, the metal usually abrades. Tribology is the science and technology of interacting surfaces in relative motion. It defines wear as the loss of material from a surface by means of some mechanical action and fretting as a small oscillatory motion between two solid surfaces in contact. Fretting wear defined as the wear arising because of fretting. The hardness of a material is strongly correlated with its wear behaviour. Photographs of the apical end of the Cer Adapt abutment from the implant shows black material on the internal hex of the Cer Adapt abutment. These debris are Titanium filings that have been abraded from the external hex of the Titanium implant.

Gurcan Eskitascioglu (2004)[34] conducted a three-dimensional finite element study to evaluate the influence of occlusal loading on stresses transferred to implant supported prosthesis and supporting bone. A three-dimensional Finite Element model of mandible (Type 2) was simulated with missing second premolar. A one piece 4.1×10mm screw shape ITI dental implant system was used. Co-Cr was used as crown framework and porcelain for occlusal surface. simulation of implant and its superstructures by Pro/Engineer 2000 I program. Total load of 300N was applied at 3 different sites. 1. Tip of buccal cusp (300 N) 2. Tip of buccal cusp(150N) and distal fossa (150 N) 3. Tip of buccal cusp(100N), Distal fossa(100N) and mesial fossa(100N). Results shows vertical loading at one point resulted on high stress values within bone and implant. Loading at 2 points created most extreme stress and 3 point loading the most even stresses within the bone.

Gehrke et al (2006)[28] Studied the fracture strength and influence of cyclic loading on retaining screw loosening. Static and cyclic loading of seven XIVE implants with straight cercon zirconium abutments were simulated under worst-case condition. Cyclic loading test were performed via a servhydraulic dynamic testing machine at loads between 100 and 450W up to 5 million loading cycles. Results shows cercon Zirconia – ceramic abutments exhibited a maximum fracture strength of 672 N during static loading and 269N at cyclic loading this clearly depicts that Zirconia abutments exceeded the established values for maximal incisal bite reported in the literature.

Att Wael et al (2006)[8]Studied the fracture resistance of single-tooth implant supported all ceramic restorations consisting of alumina all- ceramic restorations on different implant abutments and to identify the weakest component of restorative system. This study in eluded 48 standardised maxillary central incision alumina crowns (procera) were fabricated for each of and alumina abutments) to replace the implant system. The crowns were luted with resign luting agent and was artificially aged through dynamic loading and thermal cycling. All the specimens were tested for fracture resistance and the results were obtained as the median fracture for Titanium was 1454W, 422.5W and 443.6 W for Alumina and Zirconia respectively. It was found that all 3 implant supported restorations have the potential to withstand physiologic occlusal forces applied in the anterior region.

Conrad et al (2007)[19]In a comprehensive review of literalise on current ceramic materials and clinical recommendations which demonstrates that the all ceramic materials depend on the clinician's ability in appropriate selecting of the material manufacturing technique to match the intra oral functions and aesthetics.

Aboushelib et al (2007)[1]Evaluated the high fracture toughness of yttrium partially stabilized tetragonal Zirconia polycrystalline(Y-T2p) ceramics. This study used new ceria – stabilized tetragonal Zirconia Poly crystal was co-doped with alumina (ce-TZp-A1). Y-TZp was used as control. Sixty bars (20× 2.5× 1.5mm3) from each material were prepared by cutting CAD/CAM milling blocks 4-point flexural strength and modulus of elasticity were tested. The results revealed that the flexural strength and modulus of elasticity of ce-TZp were significantly weather than those of Y-TZp. The fracture toughness of former was significantly higher. Despite the promising mechanical properties of ce-TZp-41 nano composite ceramic, it's very low bond strength A high susceptible to chipping under function. Further studies are needed to enhance the surface stability of this high fracture toughness ceramic.

Guda et al (2008)[33]Examined the inherent variability of material properties, Surface interactions, and applied torque in an implant system to determine the probability of obtaining desired preload values.

This was achieved by using the software program, an abutment screw was subjected to a tightens torque and the preload was determined from finite element (FE) analysis. It was concluded that lubrication at the threaded surfaces between the abutments screw and implant bore affects the preload developed in the implant complex. For the well lubricated surfaces, only approximately 50% of implant will have preload values within the generally accepted range.

B. Yuzugullu et al (2008)[66] Conducted a study to assess the implant abutment interface after cyclic loading of Titanium, alumina and Zirconia abutments. Fifteen aluminium oxide, Zirconium oxide and Titanium abutments were connected to 3.75 × 13 MM regular platform implants secured in 30° inclined place and subjected to cyclic loading between 20W and 200W at 1 HZ on a standard contact area of cemented abutment coping, for 47.250 cycles. The measurement of micro gaps at the implant abutment interface were taken by seaming electron microscope prior to and after experiments. After dynamic loading the Titanium abutments control group revealed an increased micro gap (3.47mm) than Zirconia (1.45mm) and alumina (1.82mm) at the palatal site.

Att et al (2008)[8] Viewed the marginal adaptation of all-ceramic crowns on various implant abutments. This study used 96 standardized maxillary central incisor crowns for six test groups (48 alumina and 48 Zirconia crowns). The crowns were luted using resin cement. Marginal gaps were examined using SEM before and after luting as well as after masticatory performance. The marginal accuracy of all tested restorations meets the requirements for clinical acceptance.

Kim et al (2009)[36] Compared the fracture resistance of press able metal ceramic custom implant abutments with CAD/CAM commercially fabricated Zirconia implant abutments. This study involved 2 groups of implant abutment specimens which were custom made Pr abutments and the control group consists of CAD/CAM designed Zirconia-based ceramic (Zr) abutments. These abutments were loaded with all-ceramic crowns with the average dimension of a human central incisor for experimental and control group(n=20) using lithium dislocate press able ceramic (Ipse-Max) Crowns were cemented using resin cement. The crown abutments test specimens were fixed to Titanium implant analogy and placed in a test stand at 30 degrees from the vertical axis of the specimens in a computer-controlled universal testing device. It was found that mean (SD) fracture load was significantly higher in pr group (9d.67) than in Zr group (480.01) which eventually proves that pr abutments ore stronger than Zr abutments.

Sailer et al (2009)[49] Proposed a study to demine the difference in fracture load between internal connection Zirconia abutments with external connection Zirconia abutments. Static loading was performed according to the ISO norm 14801 until failure results the type of connection significantly influenced the strength of Zirconia abatements superior strength was achieved by means of internal connection via a secondary metallic component.

Sailer et al (2010)[50]Submitted a review on the performance of ceramic and metal implant abutments. Ceramic materials are being recommended for their biocompatibility and hatter aesthetics compared to metal.

Altogether, the studies reported on only 166 ceramic abutments vs 5683 metal abutments. A new finding added surprise 17 all ceramic crowns supported by metal abutments were lost due to fracture, while no all ceramic crowns supported by a ceramic abutment fractured. No reasons were advanced. And the other surprise was there was higher incidence of soft tissue recession et ceramic abutments. Reason postulated was that ceramic abutments are used most frequently in anterior maxilla, which has thinner soft tissue. With no surprise the Zirconia abutments had 0% aesthetic problems where's it was 66% with metal abutments. A recent systematic review found Zirconia abutments presented values of fracture strength which were not as good as conventional Titanium abutments. However, it can be used in aesthetically compromised areas. To conclude that all ceramic abutments for implants seems to be good option for long term implant restoration in aesthetic Zone. But with limited clinical studies, the application should be interpreted with caution.

De Jesus Tavarez (2010)[23] and colleagues studied the misfit alterations at the implant abutment interface of external and internal connection implant systems when subjected to cyclic loading. The study involved 5 groups with: Group 1, external hexagon implant and UCLA cast-on premachined abutment; Group 2, internal hexagon implant and premachined abutment; Group 3, internal octagon implant and prefabricated abutment; Group 4, external hexagon implant and UCLA cast-on premachined abutment; and Group 5, external hexagon implant and Ceraone abutment. Results shows 1 - Premachined abutments presented better vertical misfit than premachined cast-on abutments for external hex implant connection, for both before and after loading analysis. 2 - Cyclic loading did not influence the vertical misfit values of premachined abutments with internal and external hex connections. 3

- Cyclic loading increased vertical misfit of premachined cast-on external hex abutments and premachined octagonal internal connection abutments.

Nakamura et al (2010)[42]in a review article stated use of Zirconia as a dental implant abutment material. Due to the limited number of well-performed scientific studies published, this review concludes that at present, Zirconia abutments should be used with caution for single implant–supported restorations in the esthetic zone. Concerning its mechanical and biologic properties, Zirconia abutments seem to be as applicable as Titanium or alumina. But remains to be determined whether this assumption will hold true for follow-up periods over 5 years in prospective randomized controlled clinical trials. To optimize esthetics further, development of tooth-coloured Zirconia is necessary. In addition, the aging process of Zirconia must be studied.

Gomes et al (2011)[32] Published a review article on Zirconia implant abutments. Several studies demonstrate that Zirconia abutments offers good results at all the levels, especially in esthetic demanding thin gingival bio line. The fracture strength of Zirconia is not as good as Titanium. But relevant issues need further studies and evaluation. No literature supports with in vivo studies.

Pelaez et al (2012)[46] conducted a three-year clinical study to evaluate Zirconia posterior fixed dental prosthesis. Twenty 3-unit fixed dental prostheses were placed in 17 participants to replace a second premolar or a first molar. Restorations were cemented with a resin cement.

All fixed dental prostheses were rated satisfactory after 3 years, and no fracture of the framework was observed during the observation period. One fixed dental prosthesis was lost because of a biological complication at the 3-year examination, and a small degree of chipping of the veneering ceramic was observed in 2 participants. Within the limitations of the t study, the 3-year survival rate observed for Lava frameworks suggests that they represent a promising prosthetic treatment for posterior regions. The primary complication was chipping of the ceramic veneer. The periodontal evaluation showed good response to the Zirconia restorations except for the margin index. Several factors that may affect the rate of veneering fractures have been investigated. A loss of veneering material may result from an alteration of the crystal structure of the Zirconia surface during airborne-particle abrasion of the framework before the veneering process.

Stimmelmayr (2012)[57] and co-workers conducted a comparative study to determine the wear at interface between Titanium implant connected to Titanium abutment and Titanium implant connected to Zirconia abutment. 6 implants secured to epoxy resin blocks. Group Zr: three one-piece Zirconia abutments. Group Ti: three Titanium abutments). The abutments were loaded cyclically for 1,200,00 cycles at 100N at two-axis fatigue testing machine. The implants and abutments were examined by SEM and 3D Microcomputertomography (CT) pre and post loading. The results were compared. The Titanium implants show higher wear when connected to one-piece Zirconia abutments compared to Titanium abutments.

El -sadanay (2013)[26]studied the Fracture resistance of all ceramic crowns supported by Zirconia and alumina versus Titanium implant abutments. Group A: Titanium abutments, Group B: Al_2 O_3 alumina abutments; Group3: Zirconia abutments.48 samples were covered with ceramic crowns and loaded, representing 16 in eachgroup for 2400000 cycles to 450 N to simulate the premolar region. Then the samples were subjected to static load until the crown fractures. The samples underwent thermocycling before loading. The samples were subjected to SEM analysis. Unfavourable fracture of crown and abutment was noted in alumina abutment group (8 samples). favourable fracture occurred only in the crown in Titanium and Zirconia abutment groups. There was significant difference between the Titanium and Zirconia groups. Statistically significant higher fracture resistance was recorded with Titanium abutment group. Zirconia abutment group did not show twice the fracture resistance to alumina group. This might be due to the temperature changes during the thermocycling which altered the crystalline structure of Zirconia particles. Long time intra oral study with Zirconia is much needed.

Canullo (2013)[13] and colleagues mechanically tested the thin-walled Zirconia abutments to characterize the fatigue behaviour and the failure modes for straight and angled abutments. It was found that angled or straight thin-walled Zirconia abutments presented similar F max under fatigue testing despite the different bending moments required for fracture. But the fracture was catastrophic with straight Zirconia abutments.

Foong et al (2013)[27] in an invitro study presented the Fracture resistance of Titanium and Zirconia abutments. With 22 samples attached to implants mounted on resin block, underwent cyclic loading in a stepped fatigue loading protocol in off axial load. The differences between the groups were statistically significant for mean load and number of cycles (P<.001). For the Titanium abutment specimens, multiple modes of failure occurred. The mode of failure of the Zirconia abutments was fracture at the apical portion of the abutment without damage or plastic deformation of the abutment screw or implant., 1-piece Zirconia abutments exhibited a significantly lower fracture resistance than Titanium abutments.

Wang et al (2013)[39] conducteda research study comparing the maximum deformation and failure forces at the implant abutment interface of Titanium implants between Titanium alloy and Zirconia abutments with two levels of marginal bone loss. The Zirconia abutments can withstand physiologic occlusal forces applied in anterior region. therefore, Zirconia abutments usage should be considered in anterior region.

Cavusoglu (2014)[15] conducted a Pilot Study of Joint Stability at the Zirconium or Titanium Abutment/Titanium Implant Interface. Specimens of each restoration were subjected to cyclic axial and lateral loading of 30 N at 2 Hz for 500,000 cycles using a servohydraulic test system. Loaded Zirconia abutments were associated with wear, scratches, and, in one sample, chipping. Zirconium abutment/Titanium implant interface may be susceptible to wear of the abutment coupled with deformation of the implant neck greater than that associated with the conventional Titanium abutment/Titanium implant interface under dynamic loading.

Alqahtani (2014)[5] studied the post fatigue fracture resistance of prefabricated Zirconia implant abutments. The study concluded the preparation of pre-fabricated Zirconia abutments had a significantly negative effect on abutment load to fracture values.

Yoshiyuku Takayama (2015) [65] conducted a research on effect of bite force in occlusal adjustment of dental implants on distribution of occlusal pressure, Comparing three bite forces in occlusal adjustment. A three-dimensional finite element model of mandible with 8 implants in premolar and molar regions was constructed. Antagonists were assumed to be either natural teeth or implant. Three kinds of occlusal forces (40 N, 200N,400N) was simulated. Each model was evaluated to determine the distribution of occlusal forces on teeth and implant. It was concluded that the maximum bite force was better for occlusal adjustment of the superstructures on dental implants to prevent overloading of TMJ and of most posterior implant in vase of opposing implants.

Linkevicius (2015) [39]studied the effect of Zirconia or Titanium as abutment material on soft peri-implant tissues. The research does not support any obvious advantage of Ti or Zr abutments over each other. However, there is a significant tendency in Zr abutments evoking better colour response of peri-implant mucosa and superior esthetic outcome.

Sghaireen (2015)[49]studied the fracture Resistance and Mode of Failure of Ceramic versus Titanium Implant Abutments and Single Implant-Supported Restorations.Metal-ceramic crowns supported by Titanium abutments were more resistant to fracture than In-Ceram crowns supported by Zirconia abutments, which in turn were more resistant to fracture than IPS Empress crowns supported by Zirconia abutments. In addition, failure modes of restorations supported by Zirconia abutments were more catastrophic than those for restorations supported by Titanium abutments.

Almeida (2016) [4] studied the wear of Titanium/Titanium and Titanium /Zirconia interface in implant/abutment assemblies after thermocycling and mechanical loading. The vertices of hex of Titanium implants were worn when used Zirconia abutments the SEM images showed Zirconia particles transferred to implant, which needs further study

Linkevicius Tomas (2017)[38] **studied** he Novel Design of Zirconium Oxide–Based Screw-Retained Restorations, Maximizing Exposure of Zirconia to Soft Peri-implant Tissues. Four case reports were analyzed to describe the new design modality of Zirconia oxide screw retained restorations, in which Zirconia is exposed to the tissues and no veneering porcelain is located below the gingival margin. The article also shows the impact of this treatment on soft peri-implant tissues after 3 years of follow-up. Soft tissue recession, vestibular contour, bleeding on probing, and probing depth were evaluated. Study concluded that the novel design for Zr2O screw-retained restorations in which Zirconia is maximally exposed to peri-implant tissues offers significant advantages compared with implant-supported crowns in which subgingival parts are covered with veneering porcelain. The benefits of biocompatibility can be obtained only if the soft tissues have direct contact with the Zirconia. Therefore, it can be suggested that the biologic advantage of the traditional design for ZrO2 screw-retained restorations is limited.

Sunil Kumar Mishra (2017)[58] conducted a review study to evaluate the Microleakage at the Different Implant Abutment Interface. Maximum studies showed that there was some amount of microleakage at abutment implant interface. External hexagon implants failed completely to prevent microleakage in both static and dynamic loading conditions of implants. Internal hexagon implants mainly internal conical (Morse taper) implants are very promising in case of static loading and showed less microleakage in dynamic loading conditions.

Siadat (2017)[54]Compared the fit accuracy and torque maintenance of Zirconia and Titanium abutments for internal tri-channel and external hex implant connections. Abutments with internal connection showed less rotational freedom. However, better marginal fit was observed in externally connected abutments. Also, customized abutments with either connection could not duplicate the exact geometry of their corresponding prefabricated abutment.

Materials and Methods

MATERIALS AND METHODS

The following materials and equipment's were used for the study

- Titanium implant, internal hexagon, tapered,3.75mm diameter,10mm length, standard platform (MIS-Lance internal hex, MIS Implant Technologies, Israel) (Fig.1)
- Fibre reinforced resin block (Sinewy composite products, Ahmedabad) (Fig.2)
- MIS Implant Kit (MIS Implant Technologies, Israel) (Fig.3)
- Physio dispenser (NSK Technologies, Japan) (Fig.4)
- Titanium abutment (MIS-Standard Platform, MIS Implant Technologies, Israel) (Fig.5)
- Zirconia abutment (MIS-Standard Platform Zircon 1mm, MIS Implant Technologies, Israel) (Fig.6)
- Surgical Drill (MIS-Lance, MIS Implant Technologies, Israel) (Fig.10)
- Hex driver (MIS Implant Technologies, Israel) (Fig.11)
- Torque wrench/Ratchet (MIS Implant Technologies, Israel) (Alpha Bio Technologies, France) (Fig.12a &12b)

EQUIPMENT'S EMPLOYED:

- Custom-made cyclic loading machine (Designed & Manufactured by Lokesh Industries, Chennai) (Fig .22)
- Custom-made positioning Jig (Designed & Manufactured by Lokesh Industries, Chennai) (Fig.8)

- Scanning Electron Microscope (TESCAN, VEGA 3- England) (Fig.26)
- Image Analysis Software (Image J)
- EDAX- Energy Dispersive X ray particle Analysis (Intertek Wilton, UK) (Fig.27)

TITANIUM IMPLANT (Fig .1)

Titanium implant, Lance, Internal hexagon, tapered, 3.75mm diameter, 10mm length, standard platform (LOT NO: W15006449), (LOT NO: W14005475); ISO 13485:2003 and ISOI 9001:2008 - Quality Management System and Medical Device Directive, CE marked.

TITANIUM ABUTMENT (Fig .5)

Titanium abutment (MIS-Standard Platform, MIS Implant Technologies, Israel) Internal hexagon, standard cementing post with collar height 1mm. (LOT NO: W17000497), REF NO:MD-MAC10; ISO 13485:2003 and ISOI 9001:2008 -Quality Management System and Medical Device Directive, CE marked.

ZIRCONIA ABUTMENT(Fig.6)

Zirconia abutment (MIS-Standard Platform, MIS Implant Technologies, Israel) Zircon 1mm, Internal hex (LOT NO: WO2184312), REF NO MD -CR010; ISO 13485:2003 and ISOI 9001:2008 -Quality Management System and Medical Device Directive, CE marked.

TORQUE WRENCH/RATCHET (Fig.12a &12b)

Ratchet (Stainless steel) 75mm in length, manufactured by MIS Implant Technologies, Israel.

The torque wrench was calibrated in a professional calibrating unit (Dhaya calibrations, Madurai).

Ratchet (stainless steel) 90mm in length, manufactured by Alpha Bio Technologies, France.

The torque wrench was calibrated in a professional calibrating unit (Dhaya calibrations, Madurai).

DESCRIPTION OF THE CUSTOM-MADE CYCLIC LOADING MACHINE (Fig .22)

In the present study, a cyclic loading machine was custom-made to simulate the components in function, which permitted analysis of possible interaction between the load and the recipient. It consists of a motor with gear box, which when rotated, compressed a spring. The spring applied a load, which was transmitted to the test sample. The individual components and the calibration are described below.

SPECIFICATION OF MOTOR:

90 watts, single phase 230 V, continuous rating motor giving 350 RPM with gear reduction box of 1:18 giving a final RPM of 75 (Swipe Industries, pune. India)

SPECIFICATION OF SPRING:

Spring load ISO 10243:2010(Special springs, Rosa, Italy)

Rod Diameter -15mm

Free length of spring -50 mm.

Spring constant-48.5 N/mm.

The spring was calibrated in a professional calibration agency (MK Best Calibration Services, Chennai)

SPECIFICATION OF TIMER:

999 minutes timer with memory (k -pas, Chennai, India)

The motor was connected to an eccentric can of 2.5mm, which rotated when the motor was turned on. The 2.5mm eccentric can compressed a spring to the same length as it rotated generating a load of approximately 220N. The spring transmitted the load to the styles (3mm diameter), which transmitted a leaser load of approximately 200N to the sample due to energy loss.

DESCRIPTION OF CUSTOM-MADE POSTIONING JIG: (Fig.8)

The jig to load the sample is custom made [Lokesh Industries, Chennai]. Thecustom-made jig was fabricated with iron measuring of 13cm× 4.5cm×0.8cm in dimensions in the industrial lathe. The custom-made positioning jig was used to orient the loaded sample in cyclic loading machine. The custom-made jig consists of a platform and 4bolts. The 2 bolts on either side of the jig was used to orient the jig to the cyclic loading machine by screw driver. The other 2 bolts in the centre was used to secure the fibre reinforced resin block to the jig through a screw. The loaded sample is positioned at 90º angulation on the platform and secured with these bolts.

CALIBRATION OF THE LOADING SPRING:(Annexure 1)

The maximum and minimum loads delivered by the custom-made cyclic loading device were calibrated by a professional load calibration agency. (MK Best calibrations, Chennai)

max. load: 200N

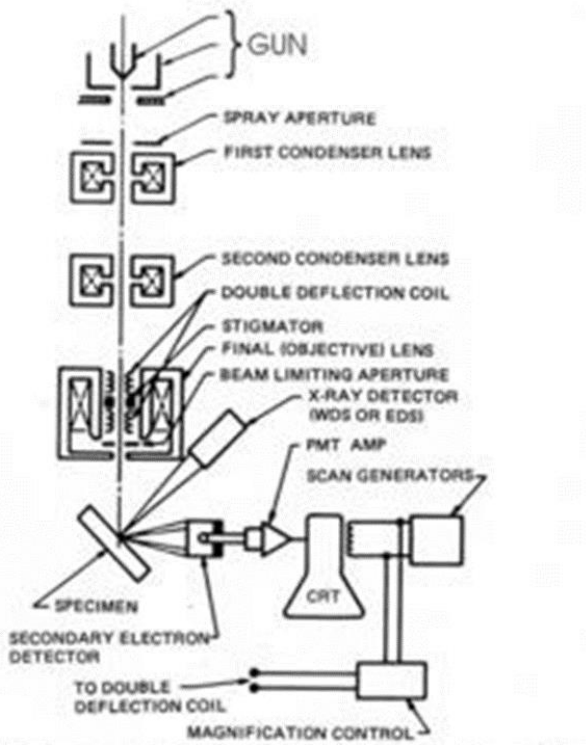
DESCRIPTION OF SCANNING ELECTRON MICROSCOPE(Fig.26)

The scanning electron microscope (SEM) uses a focused beam of high-energy electrons for generating different signals at the solid specimen surface. Information revealed by the signals that are derived from the electron -sample interactions gives information about the chemical composition, texture (external morphology), and crystalline structure. It also provides with the orientation of materials making up the sample. The collected data on a selected area of the surface can be viewed in a 2-dimensional image. Areas measuring from 1 cm to 5 microns in width with magnification ranging from 20X to approximately 30,000X, spatial resolution of 50 to 100 nm can be viewed through scanning electron microscope. This ideology is useful in qualitatively or semi-quantitatively determining chemical compositions (using EDS), crystalline structure, and crystal orientation of the sample.

A significant amount of kinetic energy is carried by the accelerated electrons in SEM. When the incident electrons are decelerated in the solid sample, this kinetic energy is dissipated as a variety of signals produced by the solid sample. These signals consist of photons (characteristic X-rays that are used for elemental analysis and continuum X-rays), secondary electrons (that produce SEM images), back scattered electrons (BSE), diffracted back scattered electrons (EBSD that are used to determine crystal structures and orientations of minerals), visible light (cathodoluminescence–CL), and heat. Secondary electrons and backscattered electrons are used to image samples. secondary electrons are useful to show topography and morphology on samples. The back scattered electrons are useful to illustrate contrast in composition in multiphase samples X-ray generation is produced by inelastic collisions of the incident electrons along with electrons in shells (discrete ortitals) of atoms in the sample. The excited electrons deteriorate to lower energy level. At this level they yield X-rays that are of a fixed wavelength which is related to the difference in energy levels of electrons in different shells for a given element. Characteristic X-rays are produced for every element in a mineral which is "excited" by the electron beam. As x-rays generated by electron interactions do not lead to volume loss of the sample, SEM is considered as "non-destructive" there by possibility of repeatedly analyzing the same sample without loss in volume.

Essential components of all SEMs include the following:

- Electron Lenses
- Sample Stage
- Power Supply
- Electron Source ("Gun")
- Display / D Cooling system
- ata output devices
- Vacuum System
- Detectors for all signals of interest
- Infrastructure Requirements:
- Vibration-free floor
- Room free of ambient magnetic and electric fields



Line diagram of scanning Electron Microscope

DESCRIPTION OF EDAX [ENERGY DISPERSIVE X RAY ANALYSIS] (Fig.27)

Energy Dispersive X-ray Analysis (EDXA) is also referred as energy dispersive X-ray microanalysis (EDXMA), Energy-dispersive X-ray spectroscopy (EDS, EDX, EDXS or XEDS). It is a technique used to analyse the elemental or chemical characterization of a sample. It depends on an interaction of some source of X-ray excitation and a sample. The fundamental principle of EDAX is that, each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum (which is the main principle of spectroscopy).

A high-energy beam of charged particles such as electrons or protons is used to stimulate the emission of characteristic X-rays from a specimen. An atom within the sample contains unexcited electrons in the discrete energy levels at rest. Ejecting an excited electron from the shell creates an electron hole, the incident beam can excite an electron in an inner shell. Then the electron from an outer, high-energy shell then fills the hole, and the difference in energy between the higher-energy shell and the lower energy shell may be released in the form of an X-ray. The number and energy of the X-rays emitted from a specimen can be calculated by an energy-dispersive spectrometer. As the energy of the X-rays differ in the energy between the two shells and of the atomic structure of the emitting element, EDAX allows the elemental composition of the specimen to be measured.

EDAX can be used to determine which chemical elements are present in a sample and can be used to estimate their relative variability. The accuracy of quantitative analysis of sample composition is thus affected by various factors.

Four primary components of the EDX setup are

- The pulse processor
- The excitation source (electron beam or x-ray beam)
- The X-ray detector
- The analyzer

Electron beam excitation is used in electron microscopes, scanning electron microscopes (SEM) X-ray beam excitation is used in X-ray fluorescence (XRF) spectrometers. A detector is used to convert X-ray energy into voltage signals and these signals are sent to a pulse processor. It measures the signals and passes them onto an analyzer for data display and analysis. The most common detector used to be Si (Li) detector cooled to cryogenic temperatures with liquid nitrogen.

METHODOLGY

The present in -vitro study was conducted to evaluate the wear resistance of Titanium and Zirconia abutments at implant-abutment interface after force transmission using cyclic loading.

The methodology adopted in the present study is described under the following sections:

I. Fibre reinforced epoxy resin block (Fig.2)

II. Parallel holes drilled in the block (Fig.7)

III. Attachment of resin block to customized jig (Fig.9)

IV. Drilling protocol for implant placement (Fig.13)

V. Positioned implants in the resin block (Fig.15)

VI. Connection of Titanium straight abutments to implants (Fig.16)

VII. Connection of Zirconia straight abutments to implants (Fig.19)

VIII. Grouping of samples

IX. Cyclic loading of Test samples (Fig.24&25)

X. Wear evaluation by Scanning Electron Microscope (Fig.26)

XI. Image Analysis

XII. Evaluation of dispersed particles by Energy Dispersive X Ray Analysis (EDAX) (Fig.27)

XIII. Data tabulation and statistical analysis

I. FIBRE REINFORCED RESIN BLOCK (Fig.2)

-SINEWY COMPOSITE PRODUCTS, AHMEDABAD.

Fibre Reinforced Epoxy resin embedding material (NEMA G 10 rod, SINEWY COMPOSITE PROUDCTS, Ahmedabad) was obtained with a diameter of 25mm. The rod was sectioned into 16mm thick blocks.

II.PARALLEL HOLES DRILLED IN THE BLOCK (Fig.7)

Holes measuring 3mm were drilled on either corner using machining lathe for connecting the resin block to the customized jig. It was ensured that the holes were completely parallel to each other.

III. ATTACHMENT OF RESIN BLOCK TO CUSTOMIZED JIG (Fig.9)

The resin block was attached to the jig by these two holes. The resin blocks were secured tightly to the customized jig by screws.

IV.DRILLING PROTOCOL FOR IMPLANT PLACEMENT (Fig.13)

The centre of the block was marked and the implant site was prepared using the physio dispenser (NSK) with 20:1 reduction gear handpiece following the classical drilling protocol. Sequential drilling with guide drill, Ø2mm twist drill, Ø2.85mm twist drill, Ø3.2mm twist drills was carried out to receive the implant to simulate implant osteotomy. Two resin blocks were prepared to receive Titanium abutments and Zirconia abutments respectively.

V. PLACEMENT OF IMPLANTS IN THE RESIN BLOCK (Fig.15)

Two Titanium implants, internal hexagon, tapered,3.75mm diameter, 10mm length (MIS-Lance internal hex) was placed in the resin block, at the crest level and torqued with MIS wrench/ratchet. The final torque was recorded to be 45 N/cm.

VI. CONNECTION OF TITANIUM STRAIGHT ABUTMENTS TO IMPLANTS (Fig.16)

To simulate the axial forces in mandibular molar region, 10 Titanium straight abutments, were connected to the implant secured in the resin blocks by torquing the abutment screw with a hex driver and ALPHA BIO torque wrench/ratchet. Final torque of 25 N/cm was given according to the manufacturer’s recommendation.

VII. CONNECTION OF ZIRCONIA STRAIGHT ABUTMENTS:

To simulate the axial forces in mandibular molar region, 10 Zirconia straight abutments, were connected to the implant secured in the resin blocks by torquing the abutment screw with a hex driver and ALPHA BIO torque wrench/ratchet. Final torque of 25 N/cm was given according to the manufacturer’s recommendation.

VIII. GROUPING OF SAMPLES:

A total of 20 samples of abutments were obtained of which, 10 were Titanium abutments connected to implant. They were designated as Group I samples connected to Titanium implant. The other 10 samples of Zirconia abutment connected to implant were designated as Group II samples.

IX.CYCLIC LOADING OF TEST SAMPLES (Fig.24, Fig.25)

Cyclic loading was performed for all twenty test samples individually, with a custom-made cyclic loading machine (Designed & Manufactured by Lokesh Industries, Chennai) to simulate oral loading conditions. The test sample was placed in a custom-made positioning jig (Designed & Manufactured by Lokesh Industries, Chennai), which positioned and secured the sample at a 90-degree angle to the floor to simulate the axial forces at the mandibular posterior region. This jig with the test sample was attached to the cyclic loading machine. The stylus of the cyclic loading machine was placed on the flattened portion of the test sample and subjected to cyclic loading. A sinusoidal waveform at 2 Hz for load up to 200 N (approximately) 25 hours (1500mins) simulating 1,80,000 cycles which was approximately 4 months of intra oral functioning. The cyclic loading was performed in a dry environment. This procedure was repeated for all the twenty test samples.

X.WEAR EVALUATION BY SCANNING ELECTRON MICROSCOPE(Fig.26)

At the completion of the cyclic loading period, the respective test sample was removed from the custom-made cyclic loading machine. Each sample was subjected to visual and tactile inspection for any deformation, abutment screw loosening. After which the test samples were subjected to Scanning Electron Microscope to evaluate the wear at the implant abutment interface. The Scanning Electron Microscope Images were recorded at 20x, 50x, 130x, 190x, 210x, 650x, 900x, 2.50kx, 4.50kx and10.50kx for all the test samples. The two implants loaded with Group I and Group II was also subjected to Scanning Electron Microscope.

XI. IMAGE ANALYSIS:

The Scanning Electron Microscope Images were converted in to numerical values using the Image Analysis Software. Image processing is a method to perform some operations on an image, to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or numerical values associated with that image. Image processing basically includes the following three steps:

- Importing the image via image acquisition tools.
- Analysing and manipulating the image.
- Output in which result can be altered image or report that is based on image analysis.

The mean area of wear and percentage area of wear of the test samples were calculated and tabulated.

XII. EVALUATION OF DISPERSED PARTICLES BY ENERGY DISPERSIVE ANALYSIS (Fig.27)

The, pre-cyclic loaded and post cyclic loaded test samples were subjected Energy Dispersive X Ray Analysis to evaluate the dispersed particles on the abutments and implants. The percentage of the dispersed particles in each sample was calculated and tabulated.

XIII. DATA TABULATION AND STATISTICAL ANALYSIS:

The data obtained were tabulated and the mean wear of the test samples for Group I and Group II were calculated. The data of 2 implants loaded with Titanium and Zirconium was also tabulated and statistically analyzed using T test and Levene's test.

METHODOLOGY -OVERVIEW

PREPARATION OF FIBRE REINFORCED RESIN BLOCK

⇓

FABRIACATION OF CUSTOMIZED JIG

⇓

RESIN BLOCK ATTACHED TO JIG

⇓

PRECYCLIC LOADING SEM ANALYSIS

⇓

PLACEMENT OF IMPLANT

⇓ ⇓

TITANIUM ABUTMENT CONNECTED TO IMPLANT	**ZIRCONIA ABUTMENT CONNECTED TO IMPLANT**

⇓

GROUPING OF SAMPLES

⇓

CYCLIC LOADING OF SAMPLES

⇓

POST-CYCLIC LOADING SEM ANALYSIS

⇓

EDAX

⇓

DATA TABULATION & STATISTICAL ANALYSIS

Figures

ANNEXURE 2

Materials,Equipments and Methodology employed

Fig.1 : 3.75 ×10 mm Implants

Fig.2: Fibre reinforced epoxy resin block of 16×25 mm dimension

Fig.3 :MIS Lance Implant kit

Fig.4 : Physio dispenser

Fig.5: Titanium abutments

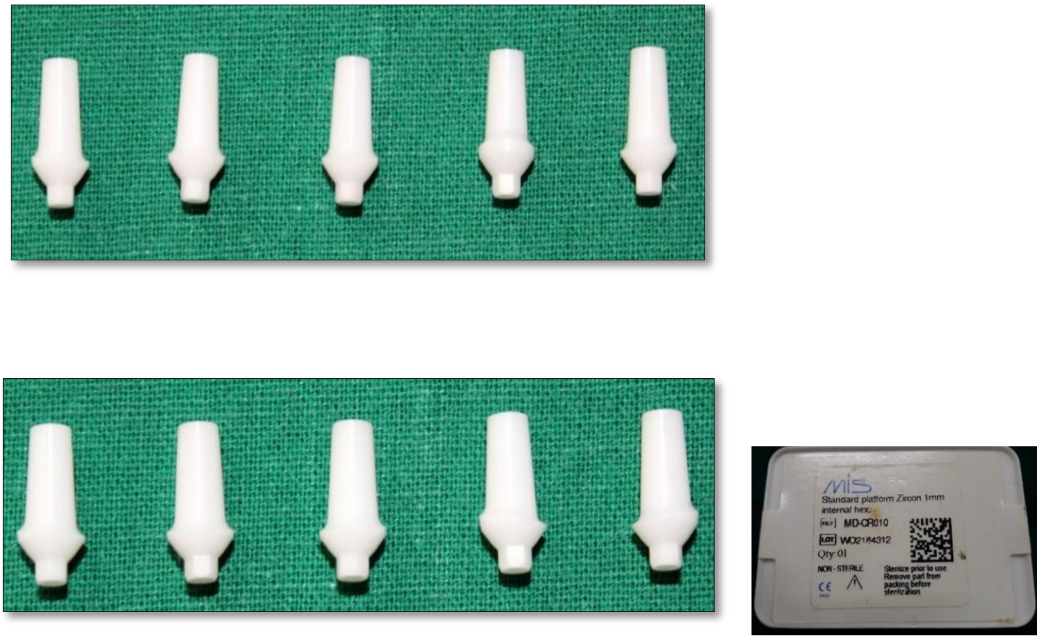


Fig.6: Zirconia abutments

Fig.7:3 mm Parallel holes drilled in the block

Fig.8 : Customized positioning jig

Fig .9:Customized jig attached to resin block

Fig.10: Surgical Drills **Fig.11: Hex driver**

Fig.12a: MIS Torque wrench/Ratchet

Fig.12b: ALPHA BIO Torque wrench/Ratchet

Fig.13: Drilling procedure for implant placement

Fig.14: Final torquing of 45 N

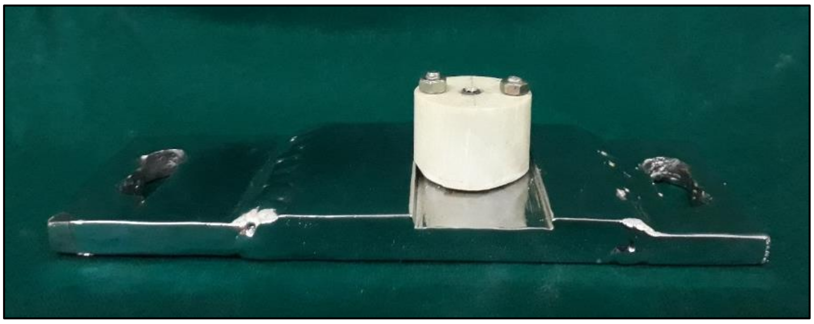


Fig.15: Positioned implant in the resin block

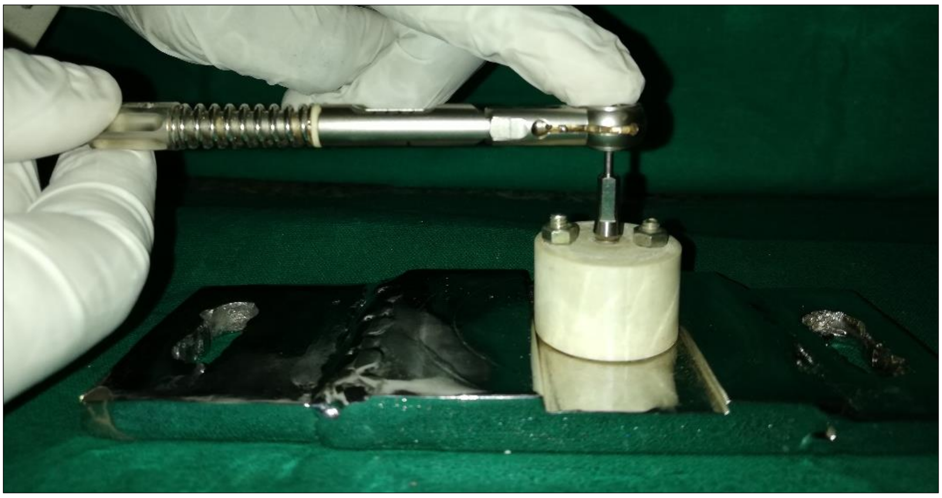


Fig.16: Titanium abutment connected to the implant with torque wrench

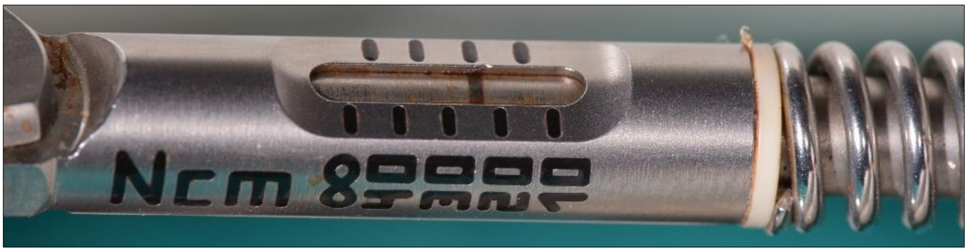


Fig .17: Final tightening of Titanium abutment to 25 N

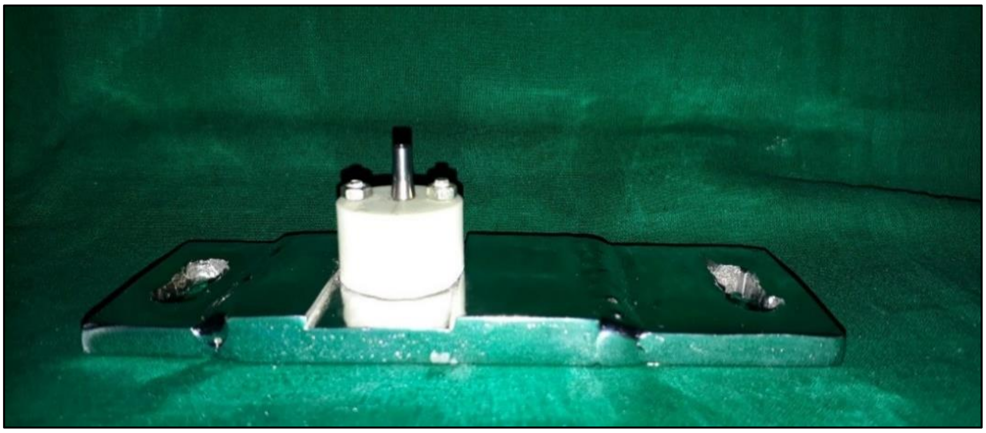


Fig .18: Customized jig with implant Titanium abutment assembly

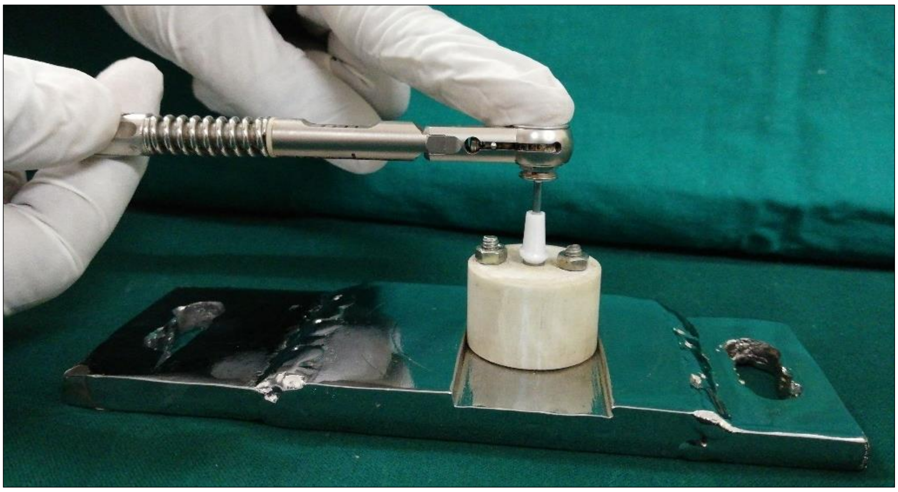


Fig.19: Zirconia abutment connected to implant with torque wrench

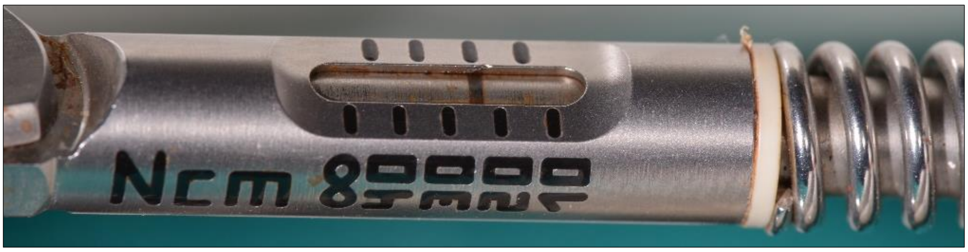


Fig .20:Final tightening of Zirconia abutment to 25 N

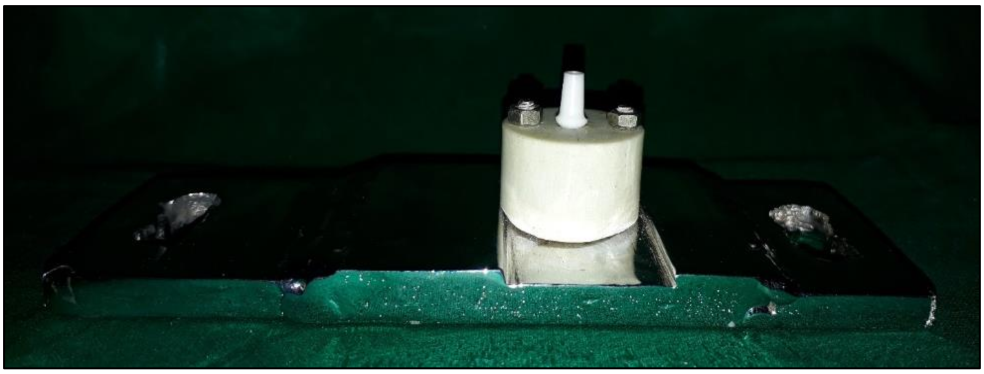


Fig .21: Customized jig with implant Zirconia abutment assembly

Fig. 22 :Customized Cyclic loading machine with Timer

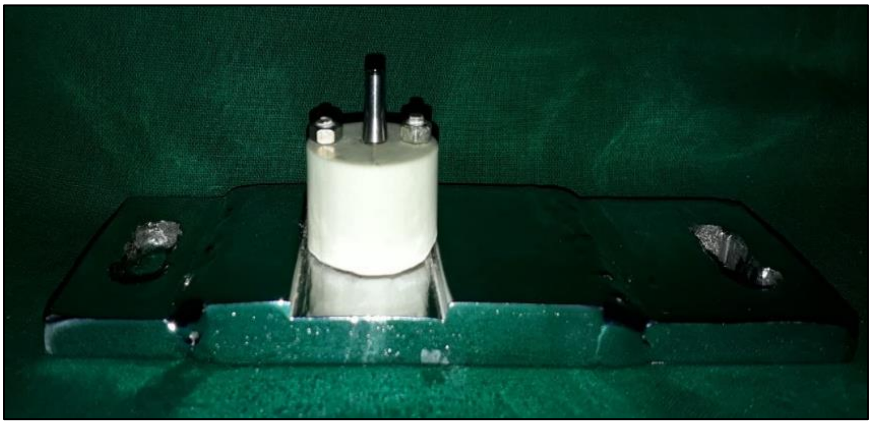


Fig.23a

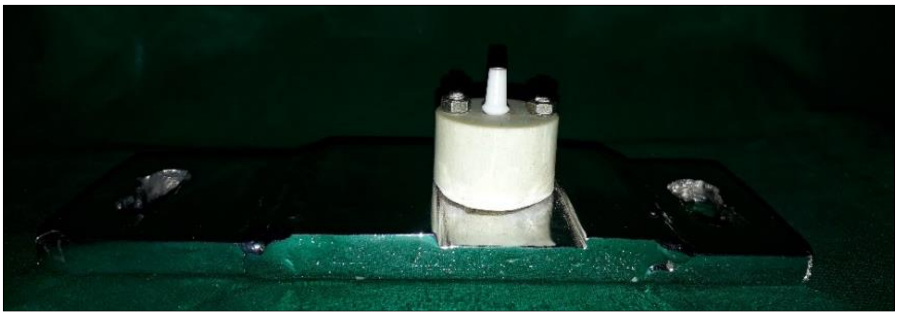


Fig.23b

Fig.23a And 23b:Customized jig with implant abutment asembly

Fig .24: Cyclic loading of Titanium abutment sample

Fig.25: Cyclic loading of Zirconia abutment sample

Fig26: Scanning Electron Microscope

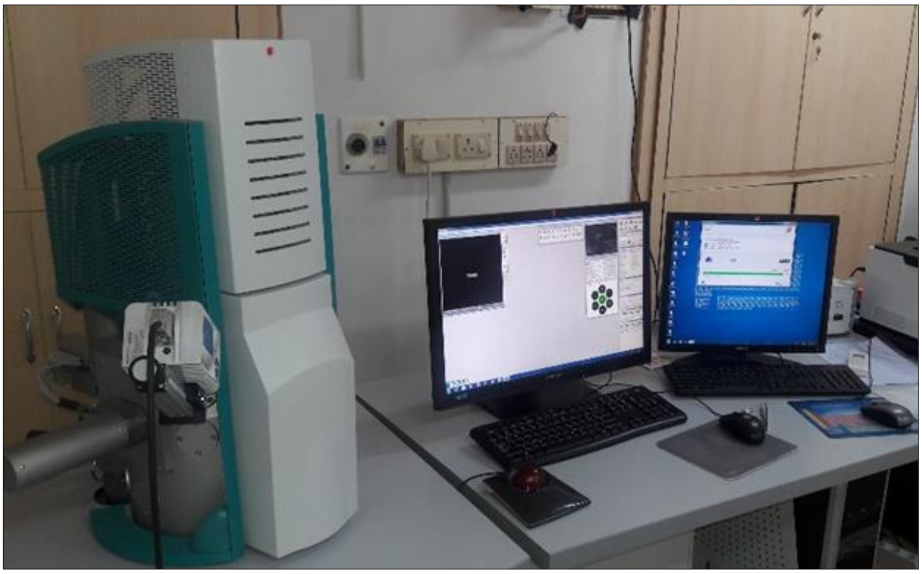


Fig.27: Energy Dispersive X Ray Analysis

Fig.28:Titanium abutments post -cyclic loading

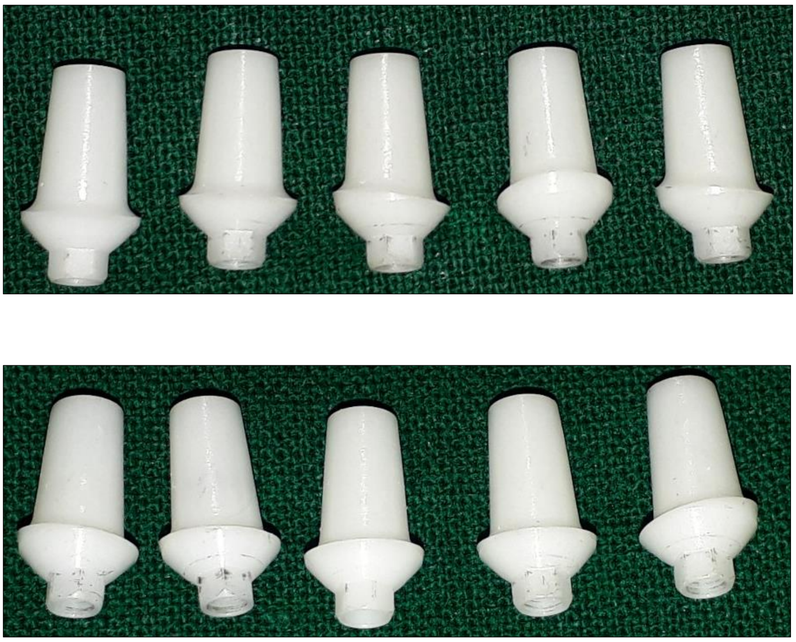


Fig.29: Zirconia abutments post -cyclic loading

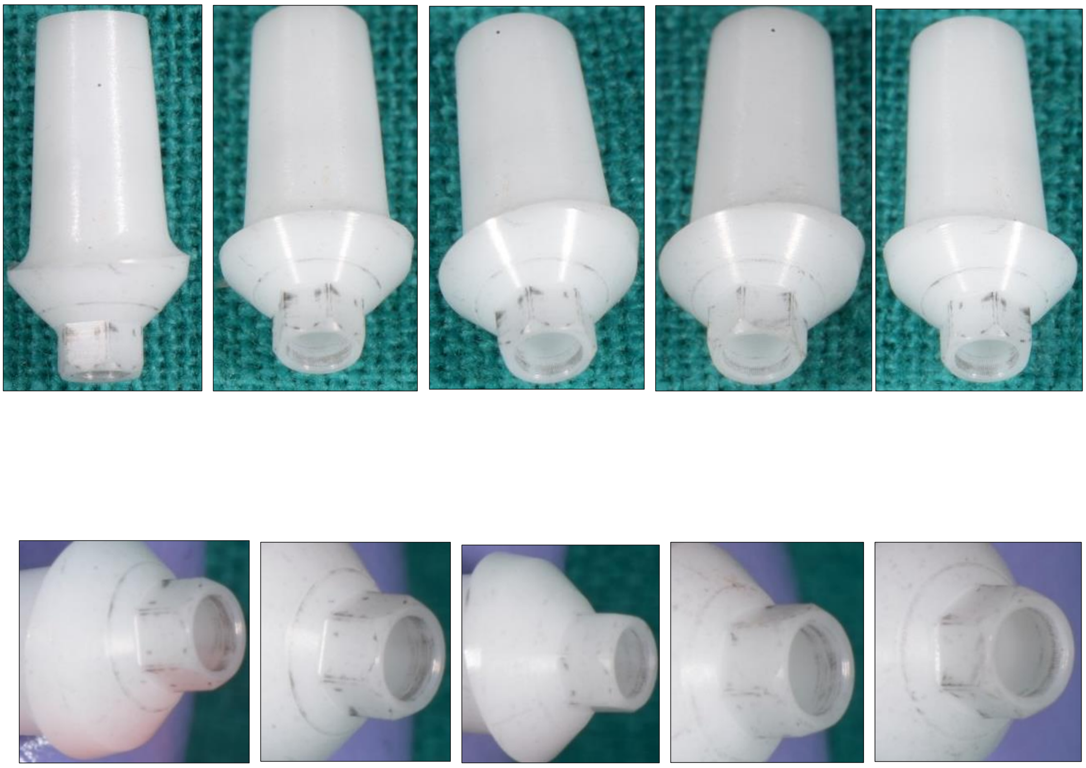


Fig .30:Concentric rings on the Zirconia abutment

Fig:31:Observation of post cyclic loaded Titanium abutment

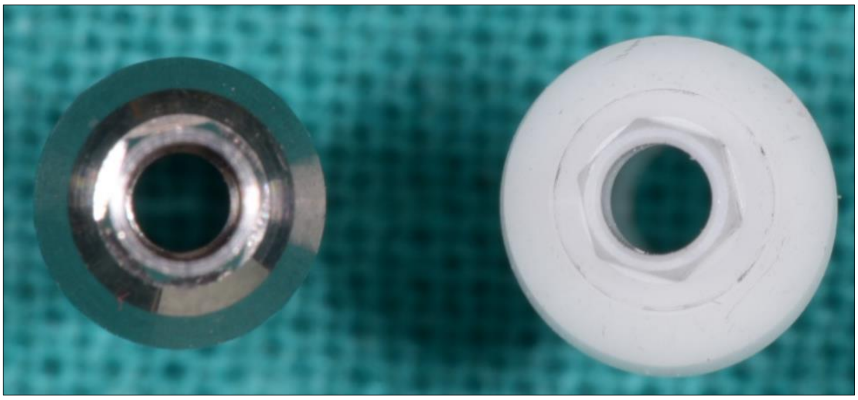


Fig.32: Comparison of post cyclic loaded Titanium and Zirconia abutment at implant -abutment interface

Fig. 33: Post -cyclic loaded implant connected to titanium abutments

Fig34: Post -cyclic loaded implant connected to zirconia abutments

Results

RESULTS

The present in - vitro study was conducted to evaluate the wear resistance during the force transmission between the Titanium and Zirconia abutment at the implant - abutment interface after cyclic loading.

In this study, Implant with standard platform (3.75× 10 mm) was connected to Titanium straight abutment (Group I), while implant with standard platform (3.75×10mm) was connected to Zirconia straight abutment (Group II) were used. All the 20 test samples – 10 Titanium straight abutments and 10 Zirconia straight abutments with 2 standard platform implants were scanned under SEM to assess the surface characteristics before cyclic loading.

All the test samples, (Group I and Group II) were subjected to cyclic loading, with a sinusoidal waveform at 2Hz of load up to 200 N for a period of 25 hours (1500mins) simulating 1,80,000 cycles which was approximately 4 months of intra oral functioning

The samples of Group I and Group II and 2 implants were subjected to Scanning Electron Microscope (TESCAN) to assess the surface wear changes at the implant - abutment interface after cyclic loading. A total of 10 images were made for each sample of each test group respectively. The photomicrographs of the Scanning Electron Microscope were converted into quantitative datas by Image Analysis software.

All the test samples of each group and 2 Implants loaded, underwent EDAX (Energy Dispersive X Ray Analysis) to examine the dispersed particles at the implant - abutment interface after cyclic loading. The values were tabulated and subjected to statistical analysis using T test and Levene's test.

Following results were drawn from the study:

TABLE I shows the quantitative analysis of surface wear of scanning electron microscope results of the post -cyclic loading Group I samples.

TABLE 2 shows the quantitative analysis of surface wear of scanning electron microscope results of the post -cyclic loading Group II samples.

TABLE 3 shows the quantitative analysis of surface wear of scanning electron microscope results at the internal hex of the Implant loaded with post -cyclic loaded Group I samples.

TABLE 4 shows the quantitative analysis of surface wear of scanning electron microscope results at the internal hex of the Implant loaded with post- cyclic loaded Group II samples.

TABLE 5 shows the EDAX percentage of dispersed particles of Titanium in post cyclic loaded Group I samples at implant- abutment interface.

TABLE 6 shows the EDAX percentage of dispersed particles of Zirconia in post cyclic loaded Group II samples at implant – abutment interface.

TABLE 7 shows the EDAX Percentage of dispersed particles of Titanium in the internal hex of Implant loaded with Group I samples.

TABLE 8 shows the Percentage of dispersed particles of Zirconia in the internal hex of Implant loaded with Group II samples.

TABLE 9 shows the comparative evaluation of surface wear of mean pre-cyclic loading and post-cyclic loading Group I samples at implant – abutment interface.

TABLE 10 shows the comparative quantitative evaluation of surface wear of mean pre-cyclic loading and post-cyclic loading Group II samples at implant – abutment interface using ‘t’ test.

TABLE 11 shows the comparative quantitative evaluation of surface wear of pre-cyclic loading and post-cyclic loading in the internal hex of implant connected to Group I samples using ‘t’ test.

TABLE 12 shows the comparative quantitative evaluation of surface wear of pre-cyclic loading and post-cyclic loading in the internal hex of implant connected to Group II samples using ‘t’ test.

TABLE 13 shows the comparative quantitative evaluation of wear of mean post cyclic loading of Group I and Group II samples at implant -abutment interface using ’t’– test and Levene’s test.

TABLE 14 shows the comparative quantitative evaluation of wear of mean post cyclic loading in the internal hex of Implants connected to Group I and Group II samples using ’t’ - test and Levene’s test.

TABLE 15 shows the comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in Group I and Group II samples at implant – abutment interface using ’t’- test and Levene’s test.

TABLE 16 shows the comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in the internal hex of Implants loaded with Group I and Group II samples using ’t’-test and Levene’s test.

GRAPH 1 shows the difference in the total area of wear between the Group I (Titanium abutments) and Group II (Zirconia abutments) samples using ‘t’ test.

GRAPH 2 shows the difference in the percentage area of wear between the Group I (Titanium abutments) and Group II (Zirconia abutments) samples using ’t’ test.

GRAPH 3 shows the difference in the total area of wear between the implants loaded with Group I (Titanium abutments) and Group II (Zirconia abutments) samples using ’t’ test.

GRAPH 4 shows the difference in the percentage area of wear between the implants loaded Group I (Titanium abutments) and Group II (Zirconia abutments) samples using ’t’ test.

GRAPH 5 shows the Percentage of dispersed particles of Titanium in Group I test sample (Titanium abutment).

GRAPH 6 shows the Percentage of dispersed particles of Zirconia in Group II test sample (Zirconia abutment).

GRAPH 7 shows the Percentage of dispersed particles of Titanium in Implant loaded with Group I test sample (Titanium abutment).

GRAPH 8 shows the Percentage of dispersed particles of Zirconia in Implant loaded with Group II test sample (Zirconia abutment).

GRAPH 9 shows the comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in Group I and Group II samples using -’t’ test.

GRAPH 10 shows the comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in Implant loaded with Group I and Group II samples using ‘t’ -test**.**

IMAGE ANALYSIS RESULTS

TABLE 1: Basic values and mean post cyclic Scanning Electron Microscope values of Group I test samples (Titanium abutment) at the implant – abutment interface.

SEM image file name	Total area of wear (μm^2)	% Area of wear
Ti 20x	6054.212	1.210
Ti 50x	8112.432	1.622
Ti 130x	9976.172	1.995
Ti 190x	10197.501	2.039
Ti 210x	9178.231	1.835
Ti 650x	12981.098	2.596
Ti 900x	9865.132	1.973
Ti 2.50kx	11809.342	2.361
Ti 4.50kx	16654.456	3.330
Ti 10.5kx	17890.543	3.578
Mean/ S. D	**10691.00/ ±5672.72**	**2.22/ ±0.99**

Inference:

For Group I test samples, the maximum percentage area of wear was 3.57% and the minimum percentage area of wear was 1.21%. The mean post cyclic Scanning Electron Microscope value was 2.22%

TABLE 2: Basic values and mean post cyclic Scanning Electron Microscope values of Group II test samples (Zirconia abutment) at the implant – abutment interface.

SEM image file name	Total area of wear (μm2)	% Area of wear
Zr 20x	13116.248	2.196
Zr 50x	10982.912	2.623
Zr 130x	15683.748	3.127
Zr 190x	26821.886	5.364
Zr 210x	48382.492	9.676
Zr 650x	59124.910	11.824
Zr 900x	89142.196	17.828
Zr 2.50kx	99482.394	19.896
Zr 4.50kx	98014.183	19.602
Zr 10.5kx	112356.199	22.471
Mean/ S. D	**60076.38/ ±47831.59**	**12.01/ ±9.56**

Inference:

For Group II test samples, the maximum percentage area of wear was 22.47% and the minimum percentage area of wear was 2.19%. The mean post cyclic Scanning Electron Microscope value was 12.01%.

TABLE 3: Basic values and mean post cyclic Scanning Electron Microscope values in the internal hex of Implant loaded with Group I (Titanium abutment) test samples.

SEM image file name	Total area of wear (µm2)	% Area of wear
Ti 20x	780.567	0.156
Ti 50x	816.339	0.163
Ti 130x	894.342	0.178
Ti 190x	963.347	0.186
Ti 210x	973.298	0.194
Ti 650x	1106.573	0.221
Ti 900x	1208.783	0.241
Ti 2.50kx	1420.739	0.284
Ti 4.50kx	1774.438	0.354
Ti 10.5kx	1963.732	0.392
Mean/ S. D	**1222.54/ ±549.39**	**0.243/ ±0.092**

Inference:

For Implant loaded with Titanium abutment samples, the maximum percentage area of wear was 0.392% and the minimum percentage area of wear was 0.156 %. The mean post cyclic Scanning Electron Microscope value was 0.243%

TABLE 4: Basic values and mean post cyclic Scanning Electron Microscope values in the internal hex of the Implant loaded with Zirconia abutments (Group II) test samples.

SEM image file name	Total area of wear (µm2)	% Area of wear
Zr 20x	790.425	0.158
Zr 50x	822.749	0.164
Zr 130x	869.186	0.173
Zr 190x	953.298	0.190
Zr 210x	1065.548	0.211
Zr 650x	1326.286	0.265
Zr 900x	1389.754	0.277
Zr 2.50kx	1811.137	0.362
Zr 4.50kx	1945.437	0.389
Zr 10.5kx	2176.779	0.435
Mean/ S. D	**1364.37 ±593.60**	**0.267 ±0.124**

Inference:

For Implant loaded with Titanium abutment samples, the maximum percentage area of wear was 0.435% and the minimum percentage area of wear was 0.158 %. The mean post cyclic Scanning Electron Microscope value was 0.267%

EDAX RESULTS

Table 5: Basic values and Mean value of dispersed particles of Titanium in Group I test sample (Titanium abutment)

Sample no	**percentage**
S1	8.28
S2	7.03
S3	7.89
S4	9.18
S5	8.46
S6	8.32
S7	7.57
S8	6.89
S9	9.91
S10	10.12
Mean /S. D	**8.3650/ ± 1.10378**

Inference:

For Group I test samples, the maximum percentage of dispersed particles was 10.12% and the minimum percentage was 6.89%. The mean percentage of dispersed particles was 8.3%

Table 6: Basic values and Mean value of dispersed particles of Zirconia in Group II test sample (Zirconia abutment)

Sample no.	Percentage %
S1	65.39
S2	60.13
S3	61.16
S4	70.39
S5	59.42
S6	62.86
S7	68.92
S8	59.14
S9	57.83
S10	59.42
Mean / S. D	**62.42/ ±4.40**

Inference:

For Group II test samples, the maximum percentage area of wear was 70.39% and the minimum percentage area of wear was 57.83%. The mean percentage of dispersed particles was 62.42%

Table 7: Basic values and Mean value of dispersed particles of Titanium at the internal hex of the Implant loaded with Group I (Titanium abutment) test samples.

Sample no.	**Percentage %**
S1	12.09
Mean / **S. D**	**12.09/** **±2.40**

Inference:

Percentage of dispersed particles of Titanium in Implant loaded with Titanium abutments was 12.09%

Table 8: Basic values and Mean value of dispersed particles of Zirconia at the internal hex of the Implant loaded with Group II (Zirconia abutments) test samples.

Sample no.	**Percentage %**
S1	56.84
Mean /	**56.84** **±8.40**

Inference:

Percentage of dispersed particles of Zirconia in Implant loaded with Zirconia abutments was 56.84%

Table 9: Comparative evaluation of surface wear of mean pre-cyclic loading and post-cyclic loading Titanium abutments at implant-abutment interface using 't'-Test

Groups	Control group	Group I
Number of samples	**10**	**10**
Mean surface wear of abutments (μm^2)	**1910.831**	**10691.00**
P -value	**0.00**	

p < 0.001 (99 %) significant

Inference:

On statistical analysis using T test it was found that the mean wear of the post – cyclic loading of Group I test values was higher than pre-cyclic loading values and it was statistically significant (p value < 0.001)

Table 10: Comparative evaluation of surface wear of mean pre-cyclic loading and post-cyclic loading Zirconia abutments at implant-abutment interface using 't'-Test

Groups	Control Group	Group II
Number of samples	10	10
Mean surface wear of abutments (μm^2)	1848.215	60076.38
P - value	0.00	

p < 0.001 (99 %) significant

Inference:

On statistical analysis using T test and it was found that the mean wear of the post – cyclic loading of Group II test values was higher than pre-cyclic loading values, and it was statistically significant (p value < 0.00)

Table 11: Comparative evaluation of surface wear of mean pre-cyclic loading and post-cyclic loading internal hex of implant connected to Group I (Titanium abutments) using 't' -Test

Groups	Control Group	Group I
Number of samples	1	1
Mean surface wear of abutments (μm^2)	765.742	1222.54
p- value	0.00	

p < 0.001 (99 %) significant

Inference:

On statistical analysis using T test it was found that the wear of the post – cyclic loading of implant connected to Group I was higher than pre-cyclic loading implants, and it was statistically significant (p value < 0.001)

Table 12: Comparative evaluation of surface wear of mean pre-cyclic loading and post - cyclic loading internal hex of the implant connected to (Group II) Zirconia abutments using 't'-Test

Groups	Control group	Group II
Number of samples	1	1
Mean surface wear of abutments (μm^2)	765.742	1364.37
P -value	0.00	

p < 0.001 (99 %) significant

Inference:

On statistical analysis, using T test it was found that the wear of the post – cyclic loading of implant connected to Group II was higher than pre-cyclic loading implants, and it was statistically significant (p value < 0.001)

Table 13: Comparative evaluation of wear of mean post cyclic loading of Titanium (Group I) and Zirconia abutment (Group II) at implant - abutment interface using 't'– test and Levene's test

Groups	Group I	Group II
Number of samples	10	10
Mean surface wear of abutments (μm^2)	10691	60076.38
Mean wear of abutments (%)	2.22	12.01
P -value	0.00	

p < 0.001 (99 %) significant

Inference: On statistical analysis using T test and Leven's test, it was found that post cyclic loading wear of Group II test samples was higher than Group I test samples and it was statistically significant (p value < 0.001)

Table 14: Comparative evaluation of wear of mean post cyclic loading at the internal hex of Implants connected to Titanium and Zirconia abutments using ‘t’–test and Levene’s test

Samples	Implant loaded with Titanium abutments	Implant loaded with Zirconia abutments
Number of samples	1	1
Mean surface wear of abutments (μm^2)	1222.54	1364.37
Mean wear of implant (%)	0.243	0.267
P - value	0.252	

$p > 0.05$ Not significant

Inference:

On statistical analysis using T test and Leven’s test, it was found that post cyclic loading wear of implant connected to Group II was higher than implant connected to Group I and it was statistically not significant (p value >0.05)

Table 15: Comparative evaluation of Mean value of dispersed particles of Titanium and Zirconia particles at implant-abutment interface using 't' -test and Levene's test

Groups	Group I	Group II
Number of samples	10	10
Mean percentage of dispersion	8.36	62.42
P -value	0.00	

$p < 0.001$ (99 % significant)

Inference:

On statistical analysis using T test and Levene's, it was found that Energy Dispersive X ray particles of Group II test samples was higher than Group I test samples and it was statistically significant (p value < 0.001)

Table 16: Comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in Implants loaded with abutments using ‘t’ -test and Levene’s test.

Sample	Implant loaded with Titanium abutments	Implant loaded with Zirconia abutments
Number of samples	1	1
Mean wear of implant (%)	12.09	56.84
P - value	0.00	

p < 0.001 (99 % significant)

Inference:

On statistical analysis using T test and Levene’s test, it was found that Energy Dispersive X ray particles of Group II test samples was higher than Group I test samples and it was statistically significant (p value < 0.001)

The present *invitro study* was done to evaluate the wear resistance of the Titanium and Zirconia abutments at the implant-abutment interface during the force transmission by cyclic loading.

The samples were subjected to Scanning Electron Microscope at the implant-abutment interface to visualize the surface characteristic changes due to wear and its equivalent quantitative analysis was done using Image Analysis Software.

Energy Dispersive X Ray Analysis was carried out for all the samples to assess the count (in percentage) of the suspended particles at the implant-abutment interface.

The test results were statistically evaluated and detailed as follows:

1. The surface wear of the post cyclic loaded Titanium abutment (Group I) at the implant - abutment interface observed under SEM at various magnification levels (20x, 50x, 130x,190x, 210x, 650x, 900x, 2.50kx, 4.50kx and 10.50kx) was in range from 1.2% to 3.57 %. (TABLE 1)
2. The surface wear of the post- cyclic loaded Zirconia abutment (Group II) at the implant - abutment interface observed under SEM at various magnification levels (20x, 50x, 130x, 190x, 210x, 650x, 900x, 2.50kx, 4.50kx, 10.50kx) was in range from 2.2%to 22.5%. (TABLE 2)
3. The surface wear of the post -cyclic implant loaded with Titanium abutment (Group I) at the level of internal hex observed under SEM at various magnification levels (20x, 50x, 130x, 190x, 210x, 650x, 900x, 2.50kx, 4.50kx and 10.50kx) was in range from 0.15% to 0.40%. (TABLE 3)
4. The surface wear of the post- cyclic implant loaded with Zirconia abutment (Group II) at the level of internal hex observed under SEM at various

magnification levels (20x, 50x, 130x, 190x, 210x, 650x, 900x, 2.50kx, 4.50kx and 10.50kx) was in range from 0.16% to 0.44%. (TABLE 4)

5. The post -cyclic loading EDAX of the Titanium abutment (Group I) at the implant- abutment interface was found to range from 6.89% to 10.12%. (TABLE5)
6. The post -cyclic loading EDAX of the Zirconia abutment (Group II) at the implant -abutment interface was found to range from 57.83% to 70.39% (TABLE 6)
7. The mean post -cyclic loading EDAX of the Implant loaded with Titanium abutment (Group I) at the level of internal hex was 12.09%. (TABLE 7)
8. The mean post-cyclic loading EDAX of the Implant loaded with Zirconia abutment (Group II) at the level of internal hex was 56.84%. (TABLE 8)
9. On comparison, the wear of mean post-cyclic loading Titanium abutment (Group I) values was higher than pre-cyclic loading values at implant-abutment interface with statistical significance (Table 9)
10. On comparison, the wear of mean post-cyclic loading Zirconia abutment (Group II) values was higher than pre-cyclic loading values at implant-abutment interface with statistical significance (Table 10)
11. On comparison, the wear of mean post -cyclic loading implant connected to Titanium abutments (Group I) was higher than pre-cyclic loading at internal hex with statistical significance (Table 11)
12. On comparison, the wear of mean post -cyclic loading implant connected to Zirconia abutments (Group II) was higher than pre-cyclic loading at internal hex with statistical significance (Table 12)

13. On comparison, the mean wear resistance of the Zirconia abutment (Group II) at the implant -abutment interface was almost 5 times lesser than the mean wear resistance of Titanium abutment (Group I) at the implant - abutment interface and it is statistically significant (TABLE 13)

14. On comparison, the mean wear resistance of the post cyclic Implant loaded with Zirconia abutment (Group II) and the mean wear resistance of the Implant loaded with Titanium abutment (Group I) at the level of internal hex was almost the same. (TABLE 14)

15. On comparison, the mean post -cyclic EDAX of Zirconia abutment (Group II) shows 7 times higher dispersion of zirconia particles compared to dispersion of Titanium particles in Titanium abutment (Group I) at the implant- abutment interface and it is statistically significant. (TABLE 15)

16. On comparison, the mean post- cyclic loading EDAX at the internal hex of Implant loaded with Zirconia abutment (Group II) showed 4 times higher dispersion of Zirconia particles than dispersion of Titanium particles at the internal hex of the implant loaded with Titanium abutment (Group I) with statistical significance. (TABLE 16)

OBSERVATION:

From the present in-vitro study, results showed that the wear resistance of the implant abutments in the descending order.

Group I > Group II

Which implies that the wear resistance during compressive force transmission up to 200N of the Titanium abutments (Group I) is 5 times higher than the Zirconia abutments (Group II) at the implant – abutment interface after 1,80,000 cycles of cyclic loading which simulated 4 months of intra oral functioning approximately. On comparison, the wear resistance in the internal hex of the implant connected to 10 Titanium abutments (Group I) and the internal hex of the implant connected to 10 Zirconia abutments (GROUP II) was statistically insignificant. The EDAX results revealed 7 times higher concentration of suspended Zirconia particles in Zirconia abutment (Group II) compared to the suspended Titanium particles in Titanium abutment (Group I) at the implant – abutment interface. The suspended Zirconia particles at the internal hex of the implant connected to Zirconia abutment (Group II) was 4 times higher than the suspended Titanium particles at the internal hex of the implant connected to Titanium abutment (Group I).

SCANNING ELECTRON MICROSCOPE IMAGES - PRE - CYCLIC LOADING

TITANIUM ABUTMENT (GROUP I)

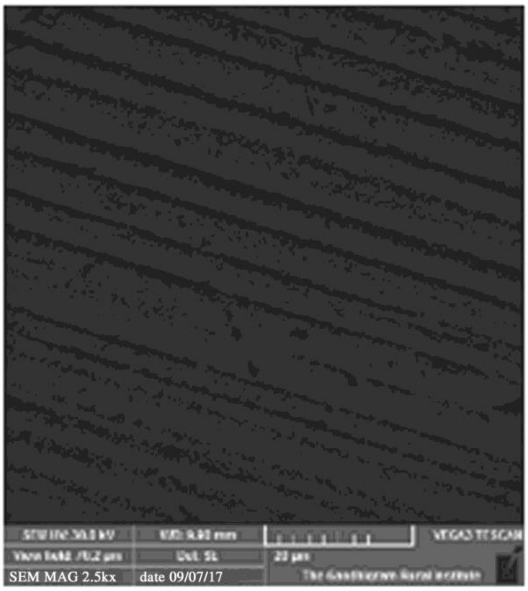


Fig .35: Under 2.5kx

ZIRCONIA ABUTMENT (GROUP II)

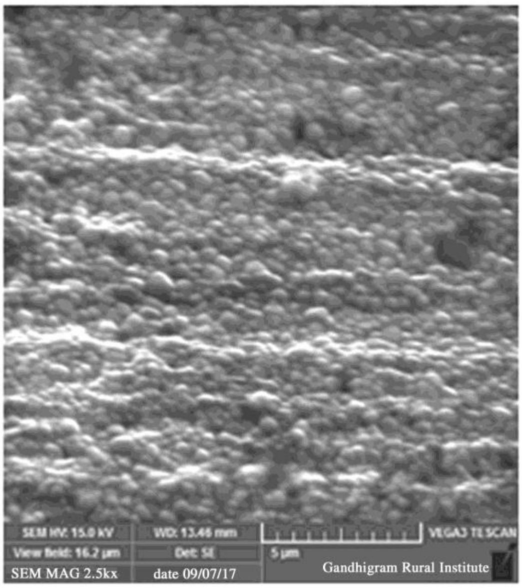


Fig. 36: Under 2.5kx

TITANIUM ABUTMENT (GROUP I)

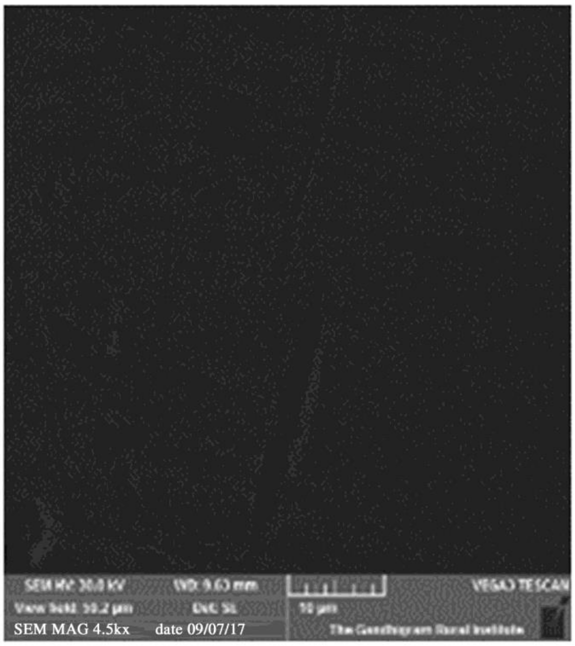


Fig.37: Under4.5kx

ZIRCONIA ABUTMENT (GROUP II)

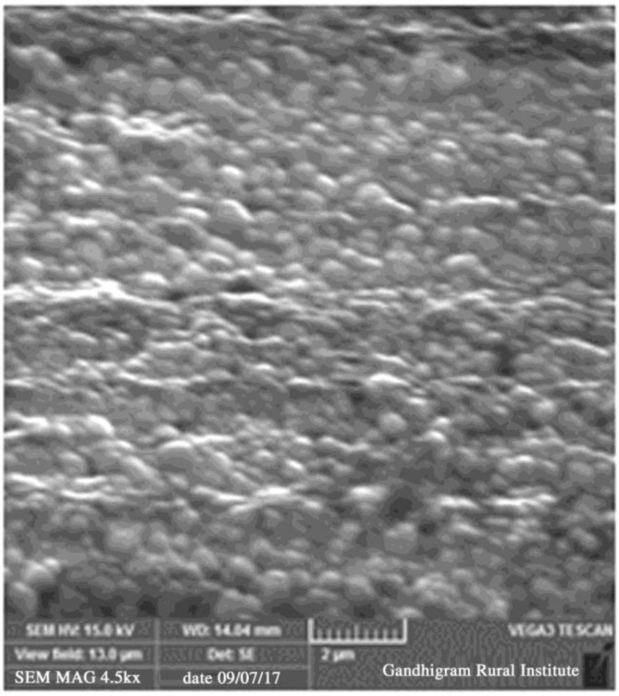


Fig.38: Under 4.5kx

TITANIUM ABUTMENT (GROUP I)

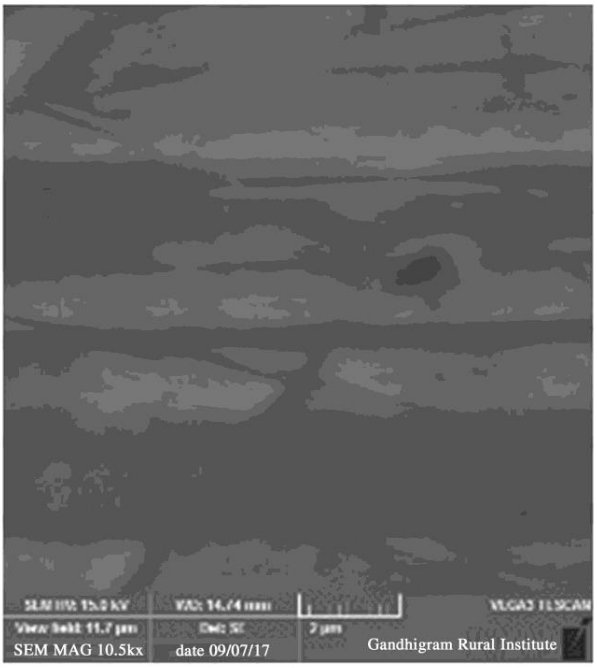


Fig.39: Under 10.5kx

ZIRCONIA ABUTMENT (GROUP II)

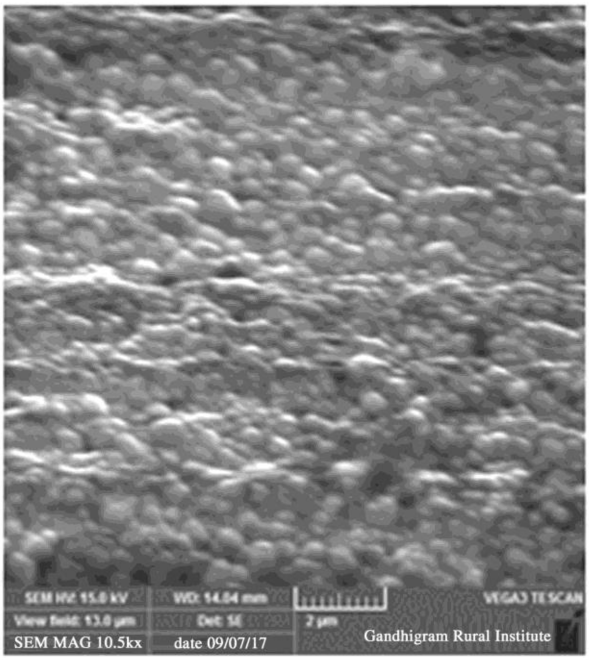


Fig.40:Under10.5kx

SCANNING ELECTRON MICROSCOPE IMAGES – POST- CYCLIC LOADING

TITANIUM ABUTMENT (GROUP I)

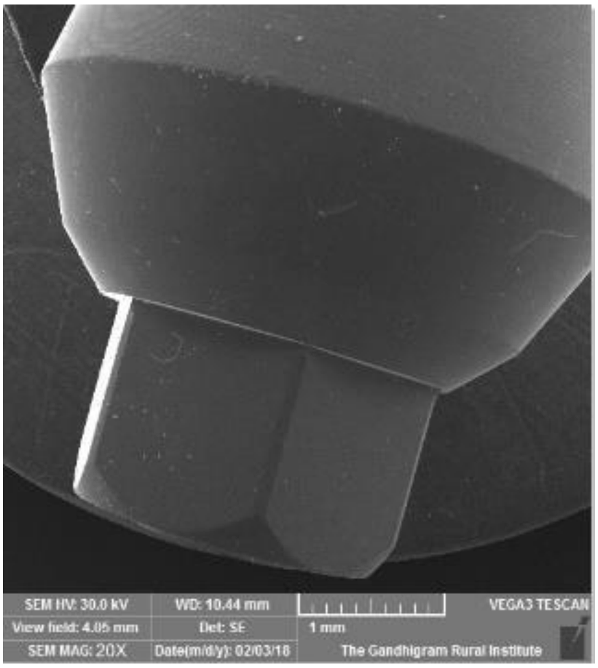


Fig.41: Under 20 x

ZIRCONIA ABUTMENT (GROUP II)

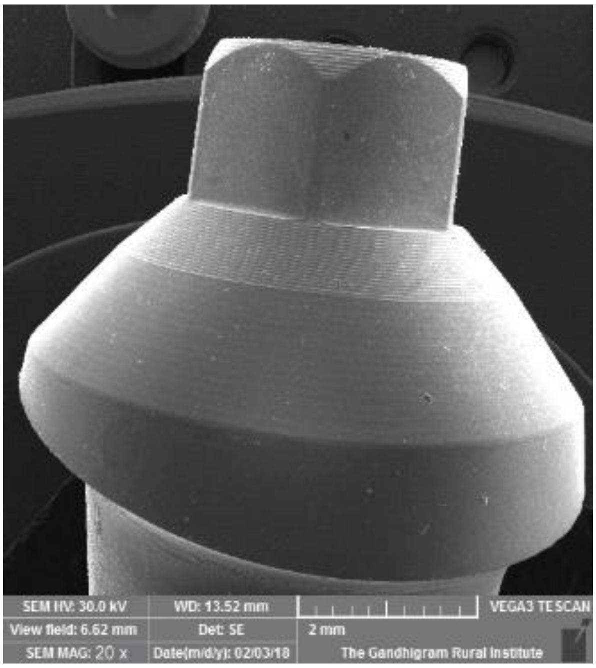


Fig.42: Under 20 x

TITANIUM ABUTMENT (GROUP I)

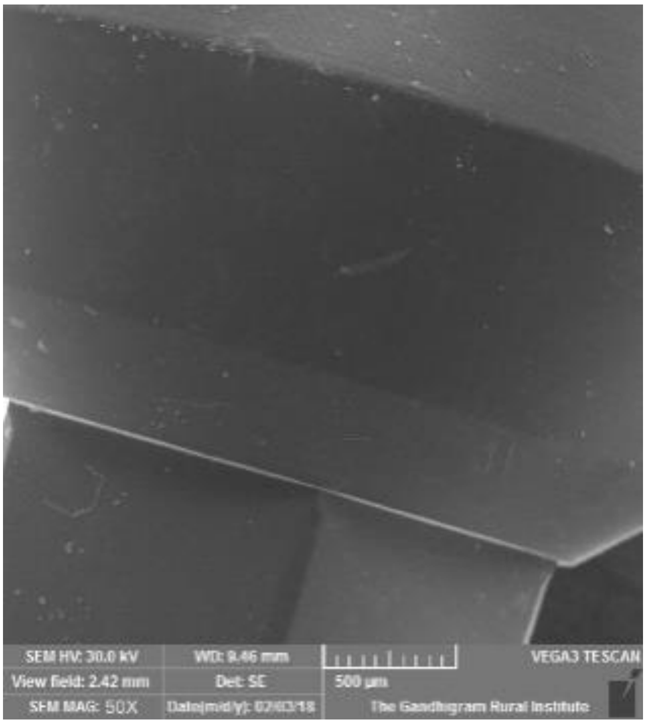


Fig .43: Under 50 x

ZIRCONIA ABUTMENT (GROUP II)

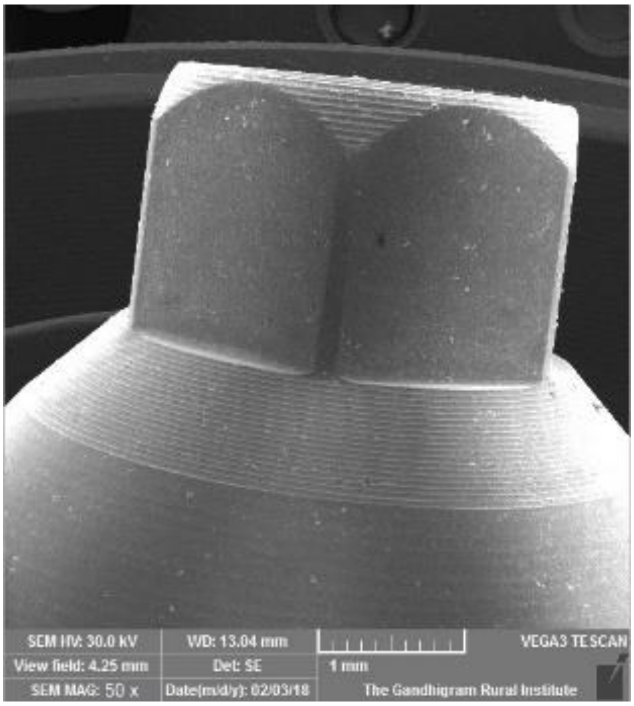


Fig.44: Under 50 x

TITANIUM ABUTMENT (GROUP I)

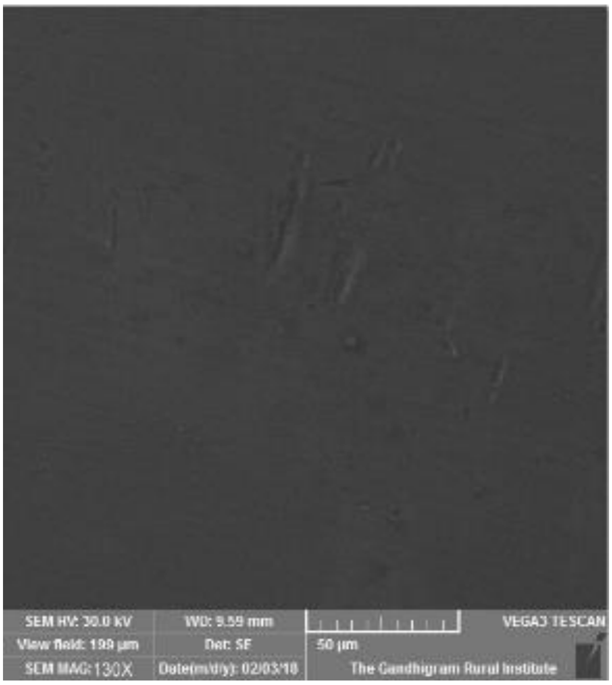


Fig.45:Under 130x

ZIRCONIA ABUTMENT (GROUP II)

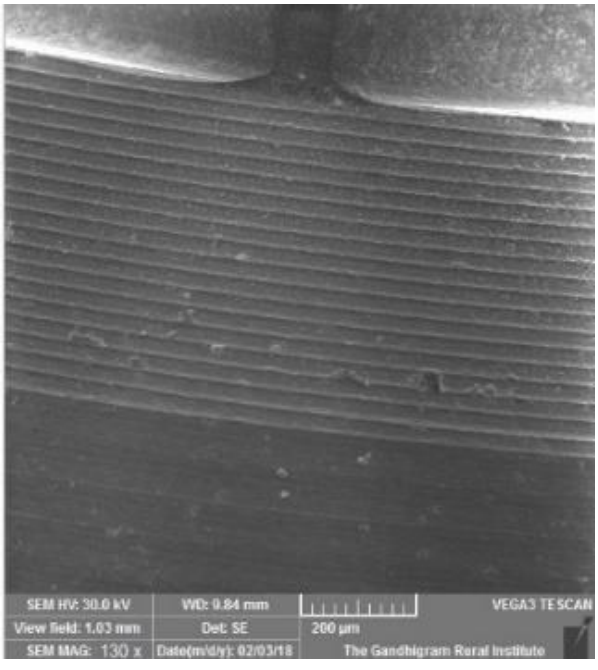


Fig.46: Under 130x

TITANIUM ABUTMENT (GROUP I)

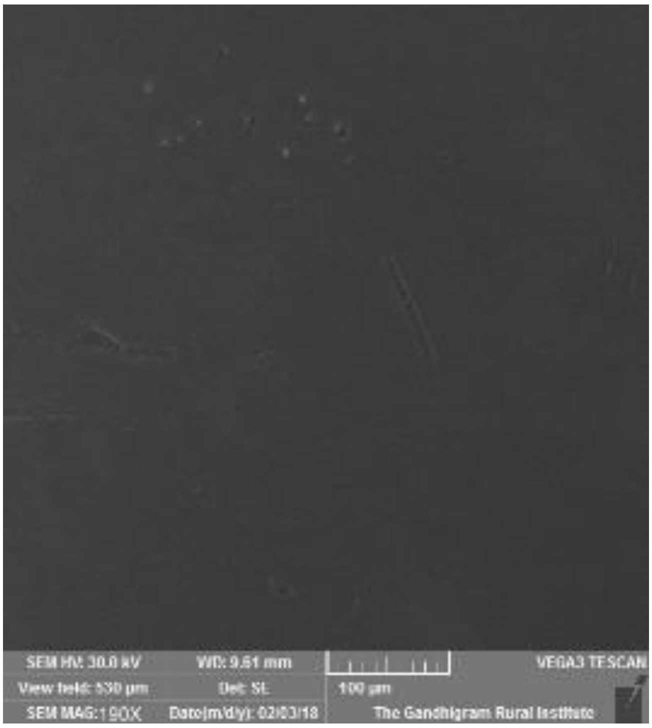


Fig .47: under 190x

ZIRCONIA ABUTMENT (GROUP II)

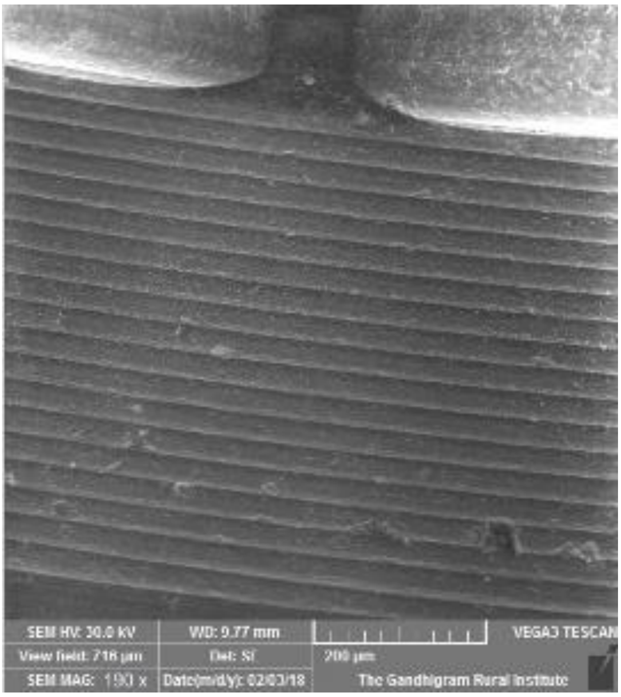


Fig .48: Under 190x

TITANIUM ABUTMENT (GROUP I)

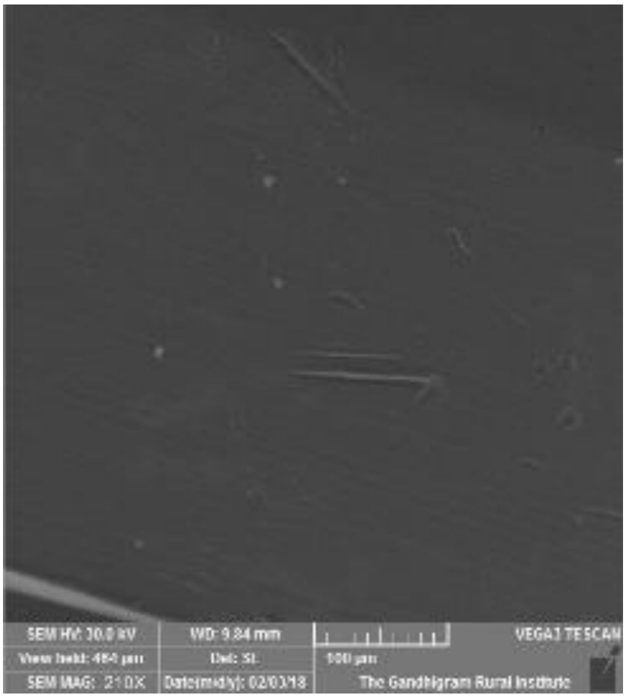


Fig.49: Under 210x

ZIRCONIA ABUTMENT (GROUP II)

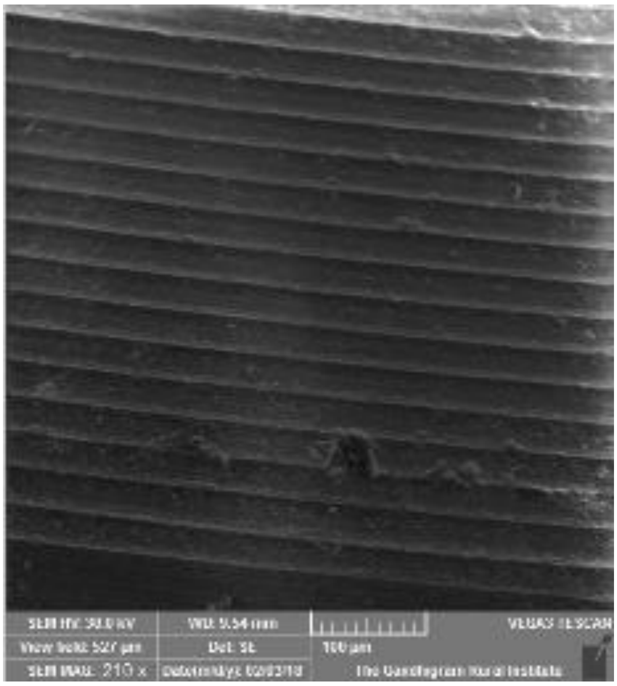


Fig .50: Under 210x

TITANIUM ABUTMENT (GROUP I)

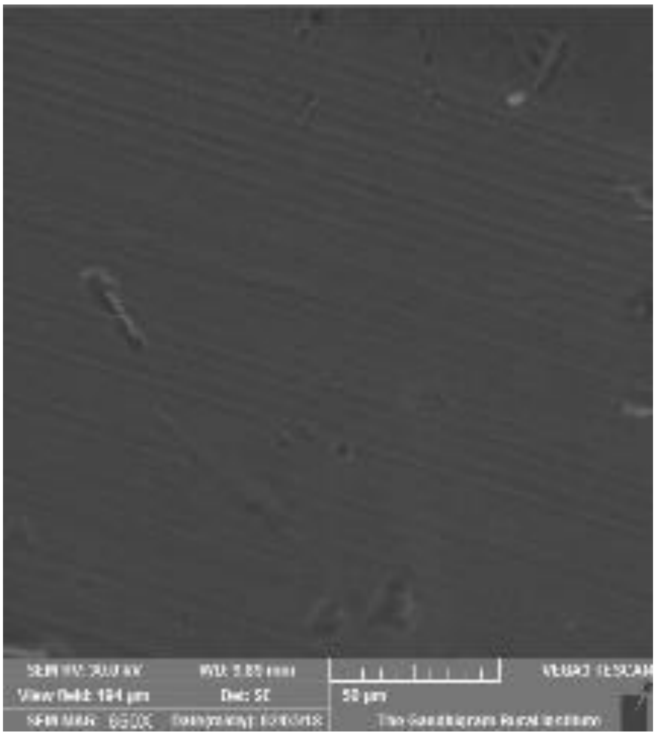


Fig .51: Under 650x

ZIRCONIA ABUTMENT (GROUP II)

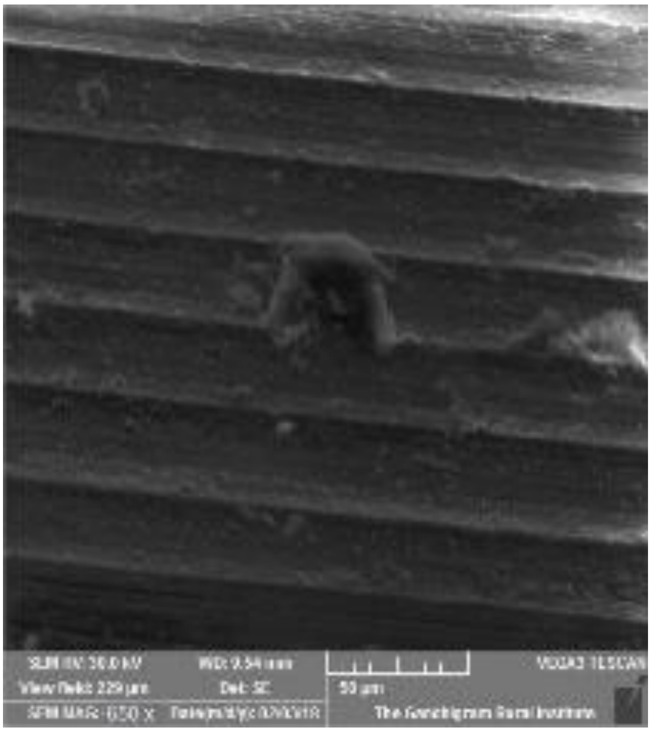


Fig.52: Under 650x

TITANIUM ABUTMENT (GROUP I)

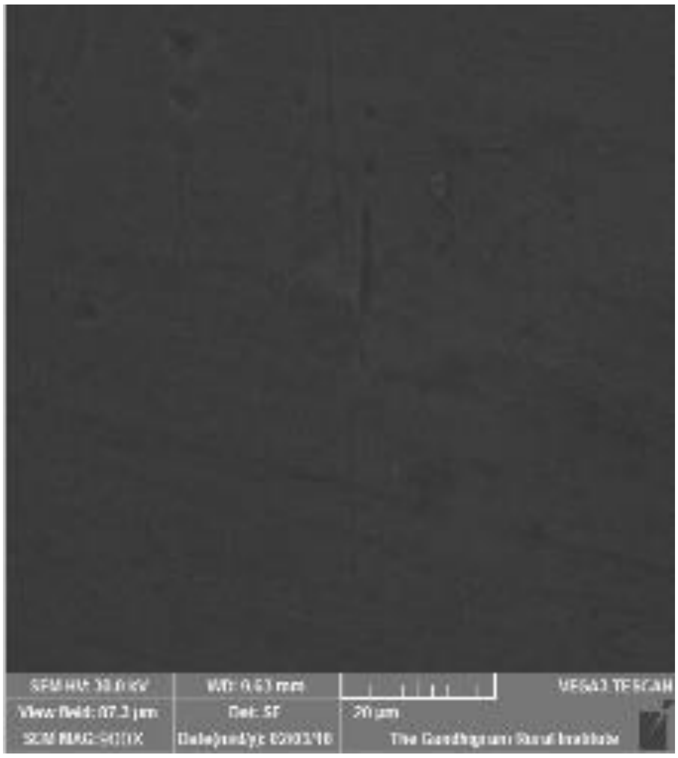


Fig .53: Under 900x

ZIRCONIA ABUTMENT (GROUP II)

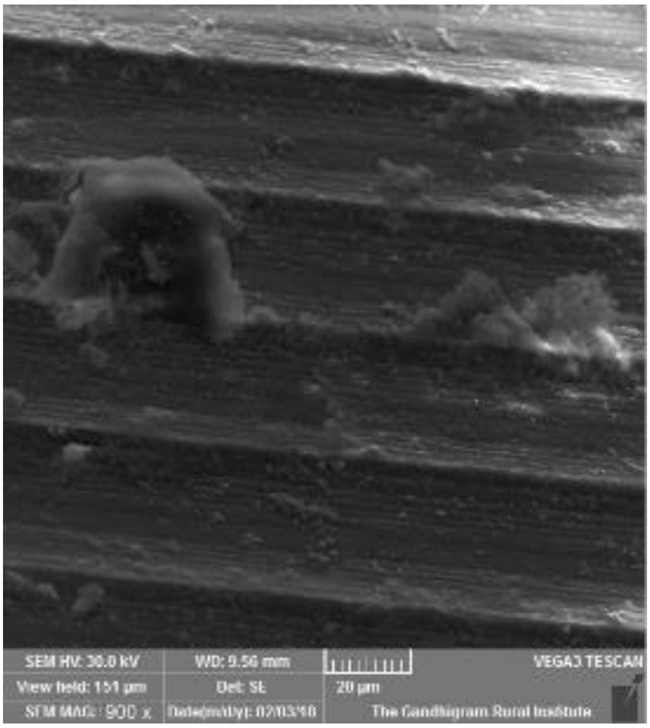


Fig.54: Under 900x

TITANIUM ABUTMENT (GROUP I)

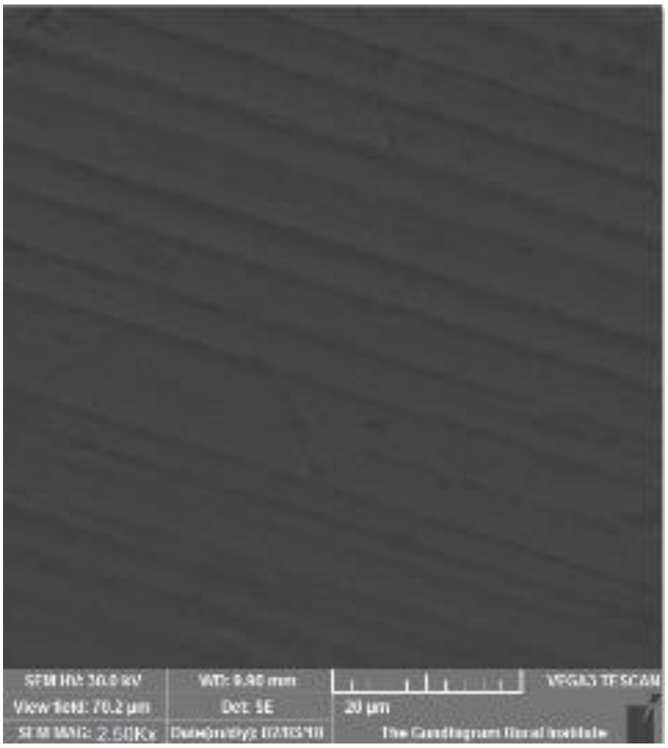


Fig .55: Under 2.5kx

ZIRCONIA ABUTMENT (GROUP II)

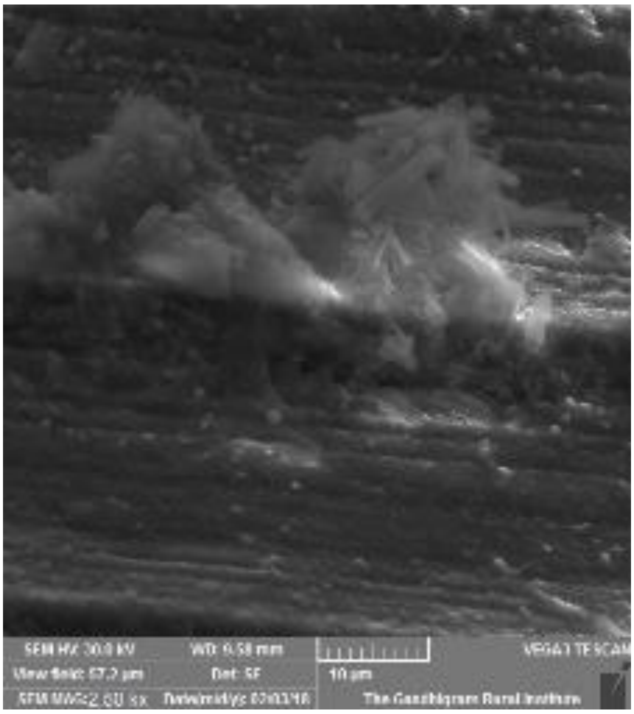


Fig.56:Under2.5kx

TITANIUM ABUTMENT (GROUP I)

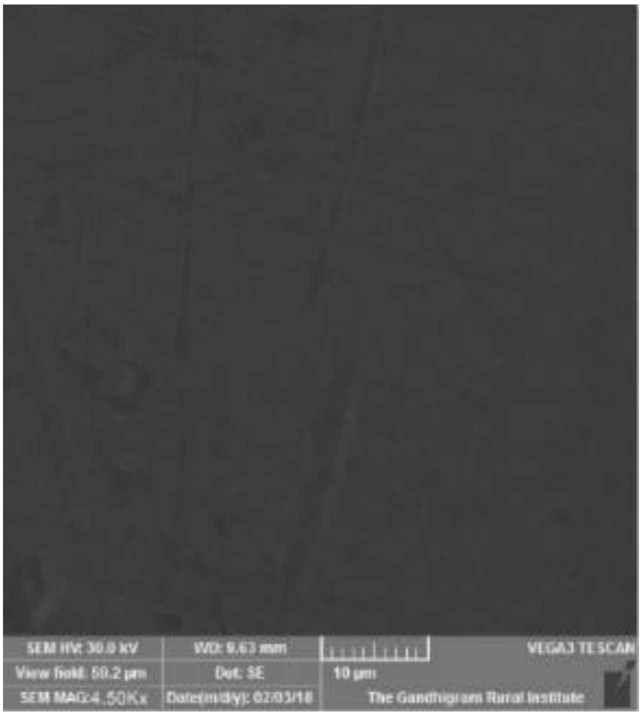


Fig .57: Under 4.50kx

ZIRCONIA ABUTMENT (GROUP II)

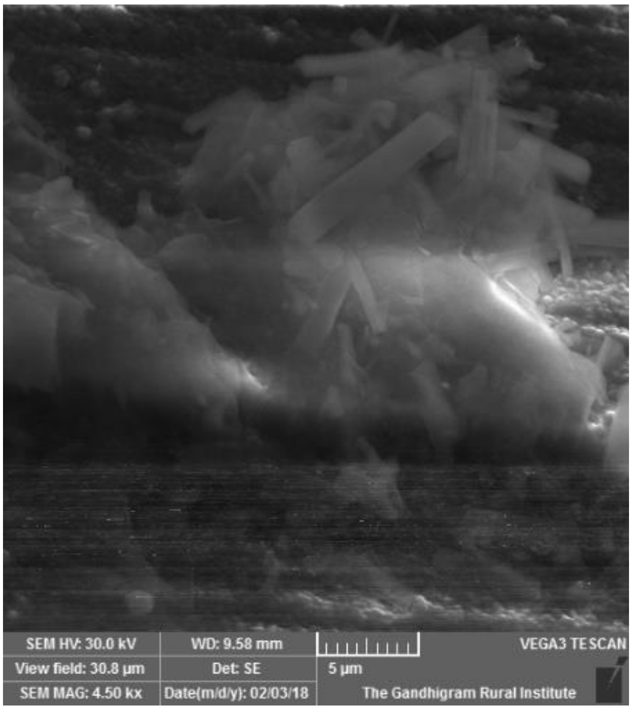


Fig. 58: Under 4.50kx

TITANIUM ABUTMENT (GROUP I)

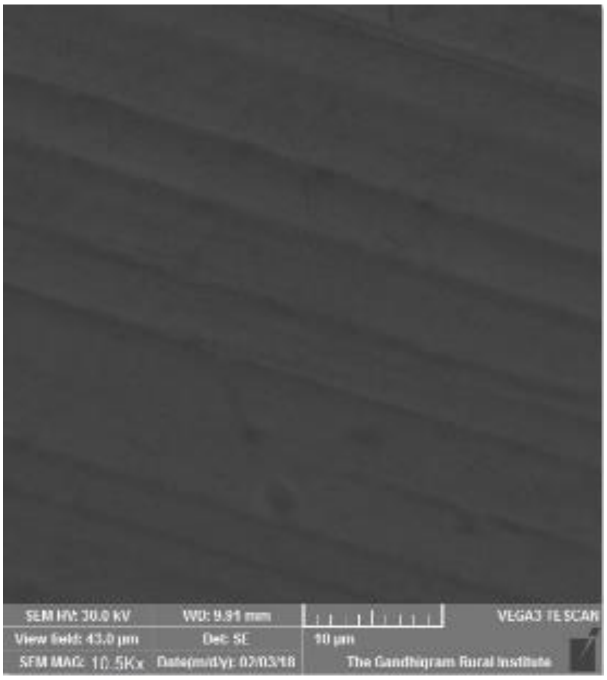


Fig .59:Under 10.50kx

ZIRCONIA ABUTMENT (GROUP II)

Fig.60:Under 10.50kx

COMPARISON OF PRECYCLIC LOADING AND POST CYCLIC LOADING OF TITANIUM ABUTMENTS AT VARIOUS MAGNIFICATION LEVEL

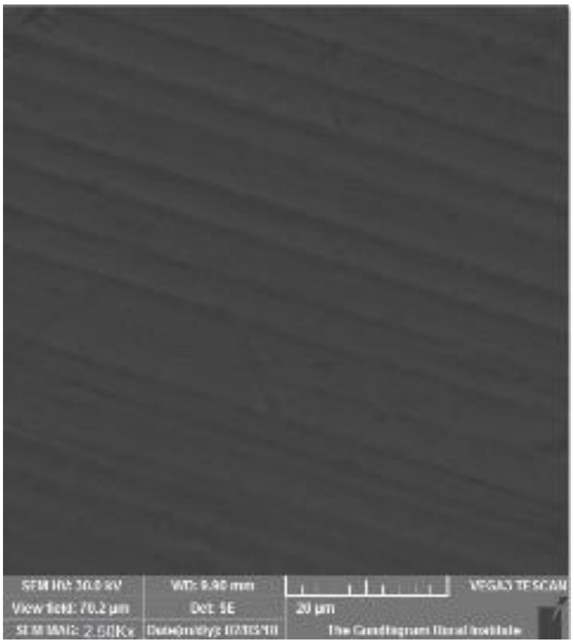


Fig .61: Pre-cyclic loading

Under 2.5kx

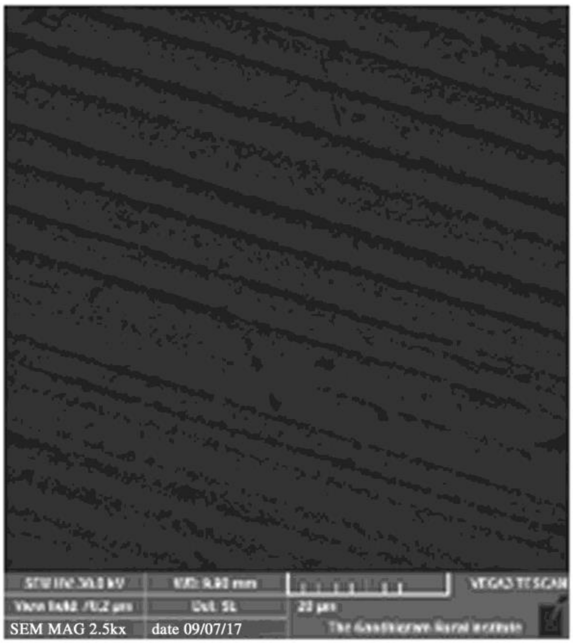


Fig.62: Post -cyclic loading

Under 2.5kx

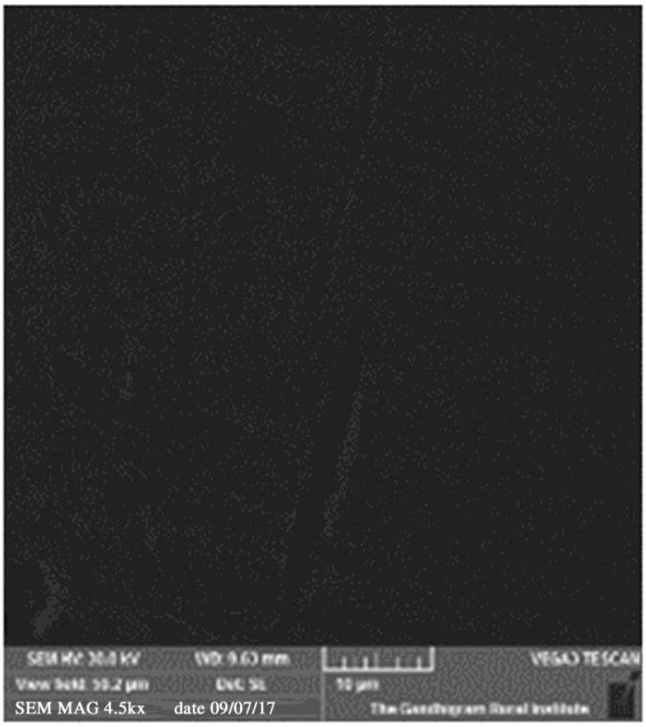


Fig.63: Pre-cyclic

Under 4.5kx

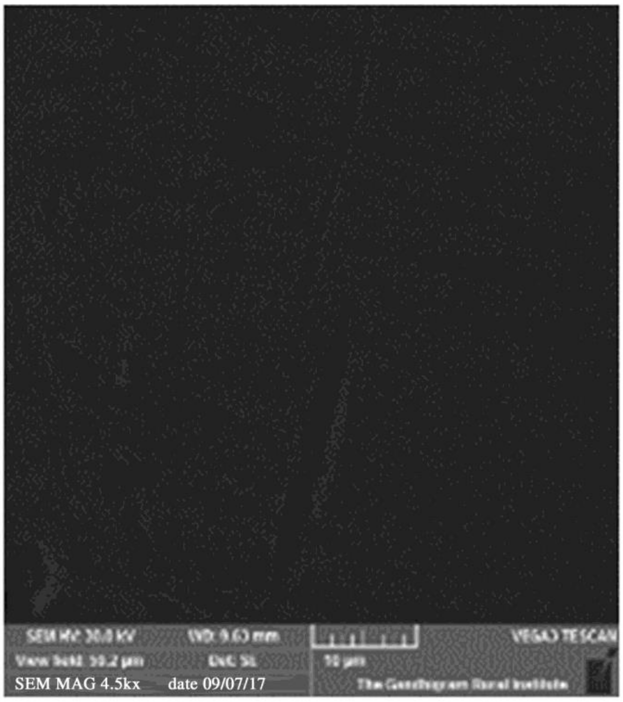


Fig.64: Post-cyclic loading

Under 4.5kx

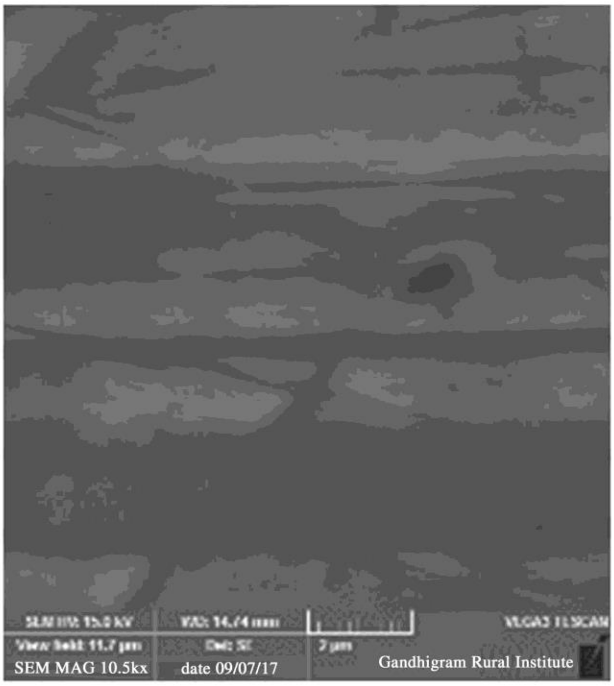


Fig.65: Pre-cyclic loading

Under 10.50kx

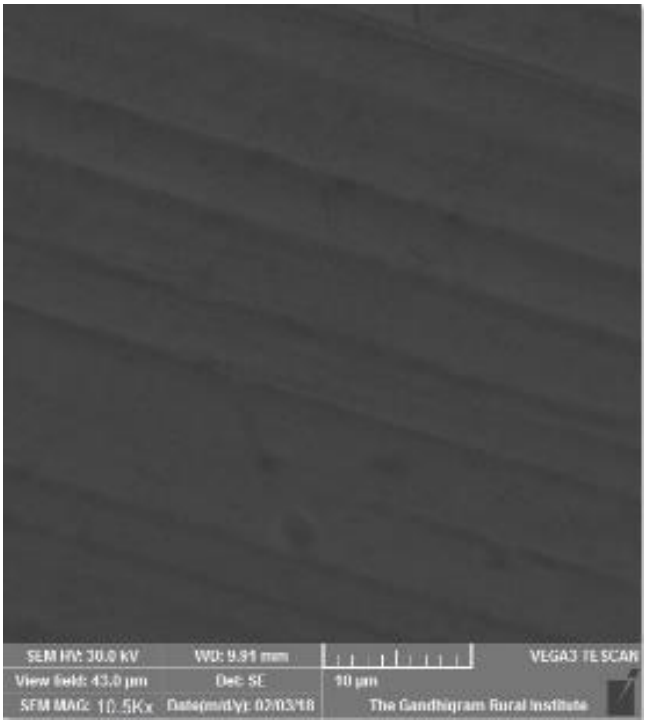


Fig.66: Post-cyclic loading

Under 10.50kx

COMPARISON OF PRECYCLIC LOADING AND POST CYCLIC LOADING ZIRCONIA ABUTMENTS AT VARIOUS MAGNIFICATION LEVELS

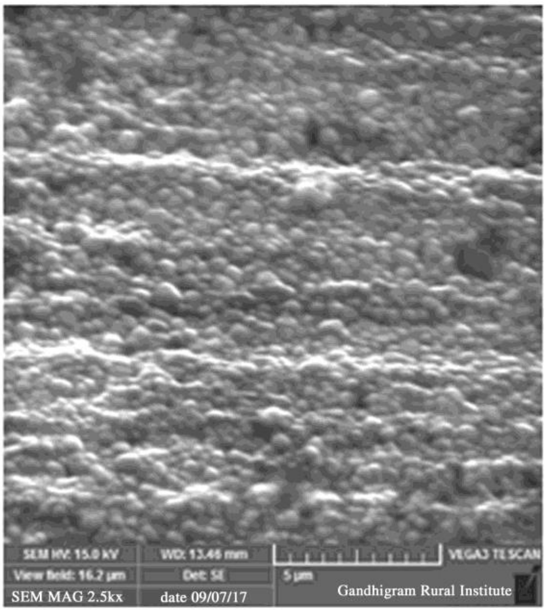


Fig.67: Pre-cyclic loading

Under 2.50kx

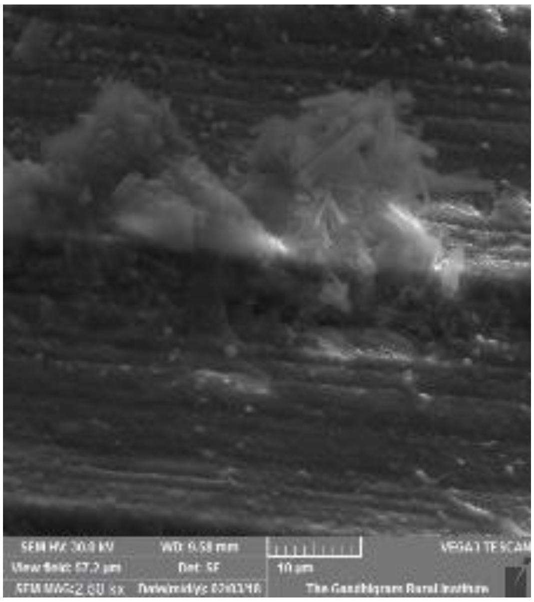


Fig.68: Post-cyclic loading

Under 2.50kx

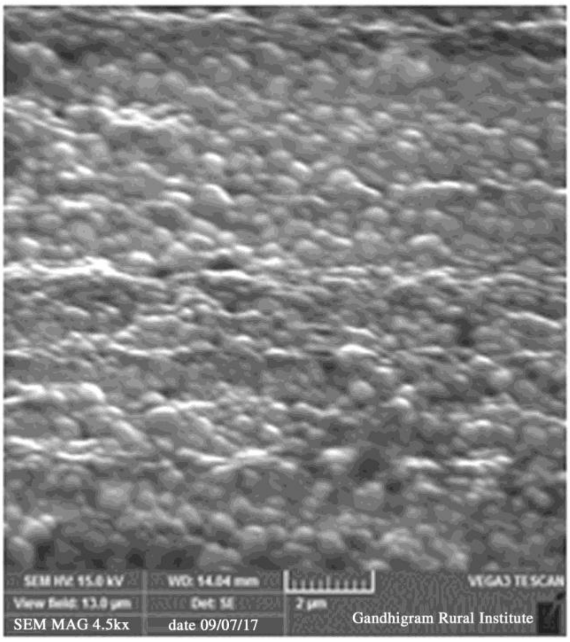


Fig.69: Pre-cyclic loading

Under 4.50kx

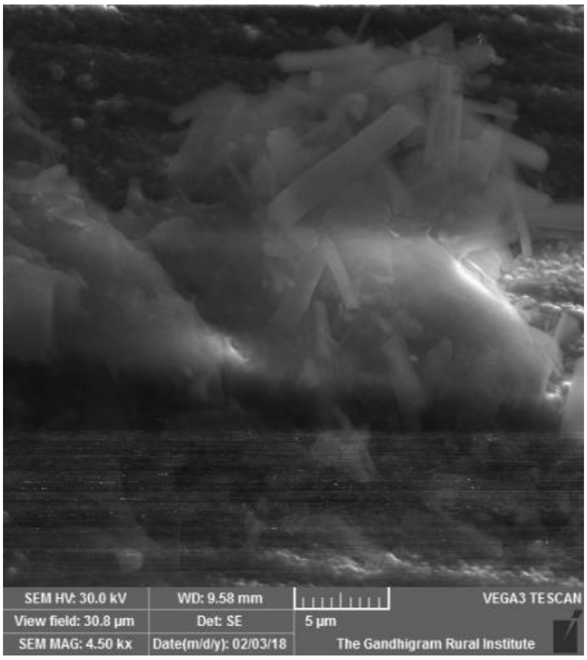


Fig.70: Post-cyclic loading

Under 4.50kx

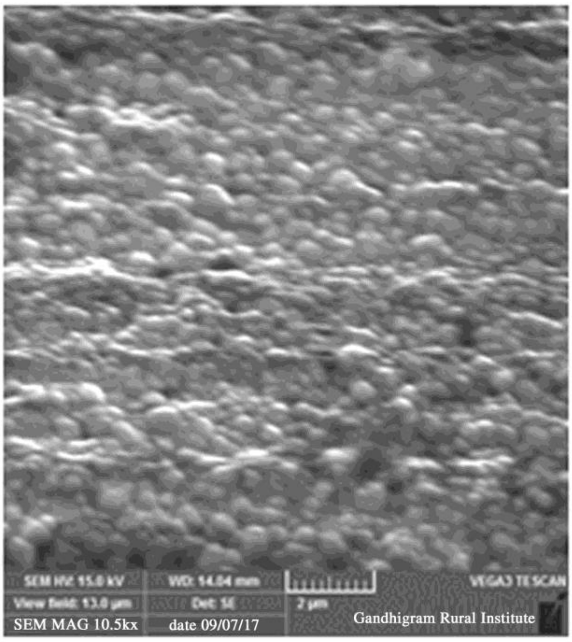


Fig.71: Pre-cyclic loading

Under 10.5kx

Fig.72: Post-cyclic loading

Under 10.5kx

SEM IMAGES OF IMPLANTS PRE- CYCLIC LOADING

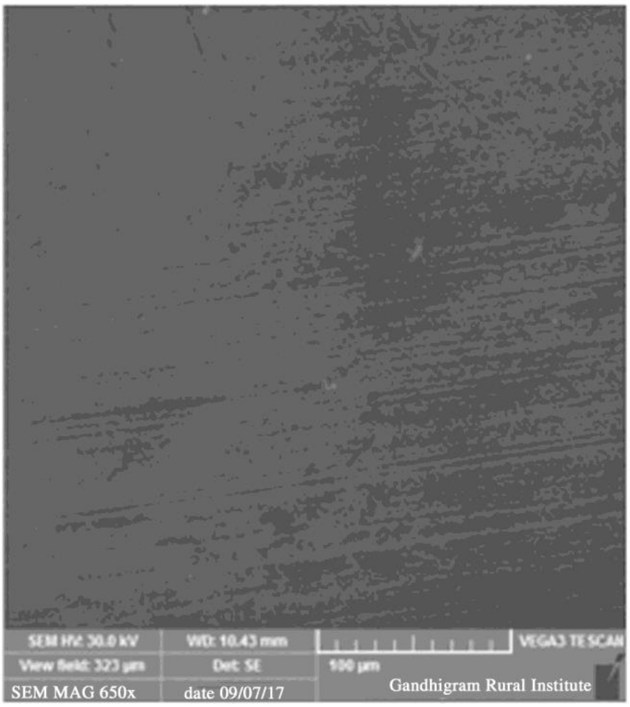


Fig.73: Under 650x

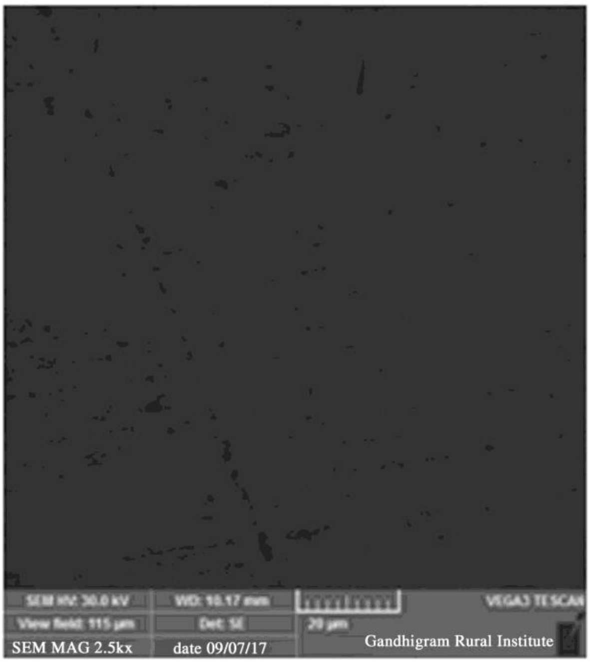


Fig.74: Under 2.5k

SEM IMAGES – IMPLANT POST – CYCLIC LOADING

TITANIUM ABUTMENT LOADED

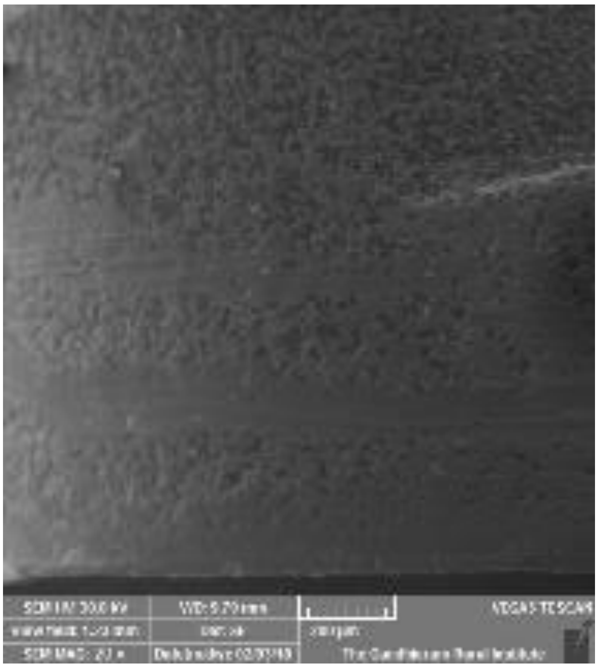


Fig.75:Under 20x

ZIRCONIA ABUTMENT LOADED

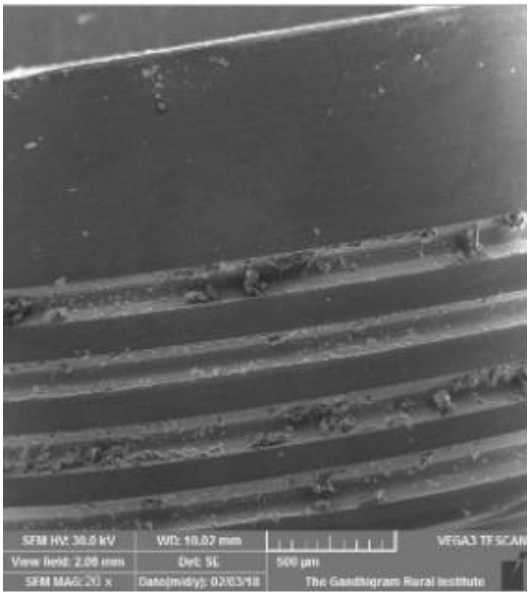


Fig.76: Under 20x

TITANIUM ABUTMENT LOADED

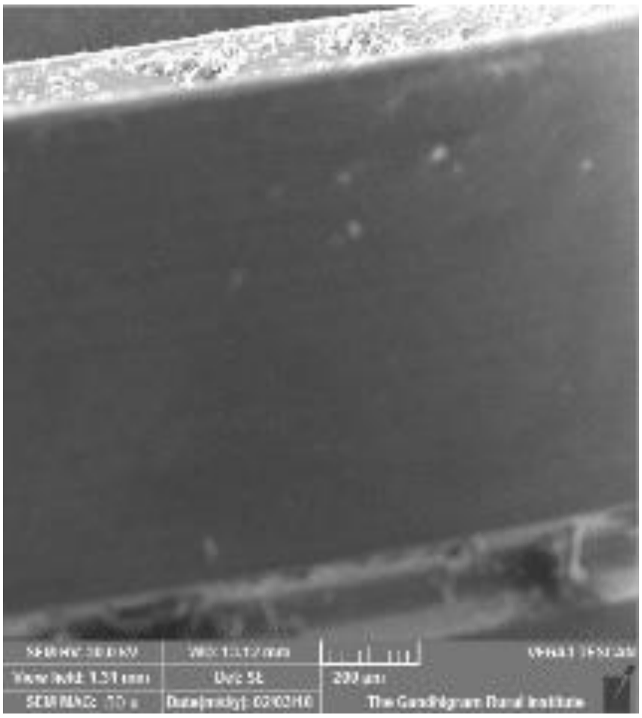


Fig.77: Under 50x

ZIRCONIA ABUTMENT LOADED

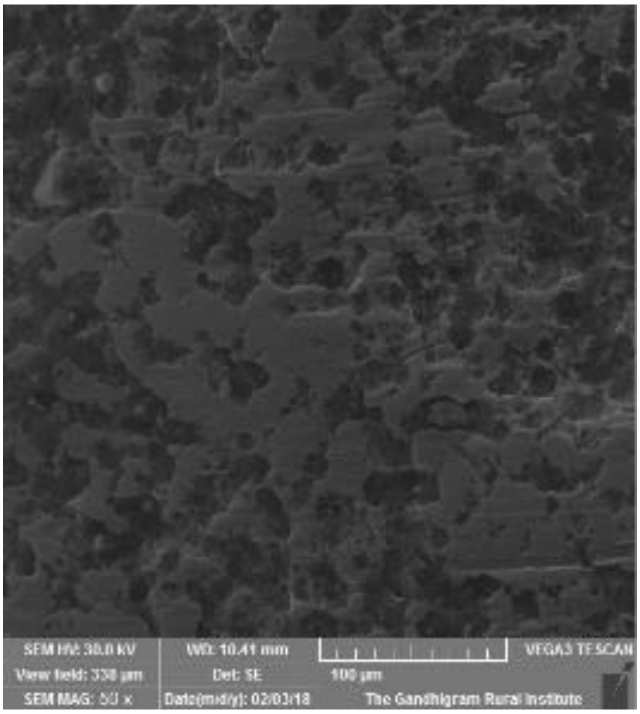


Fig .78: Under 50x

TITANIUM ABUTMENT LOADED

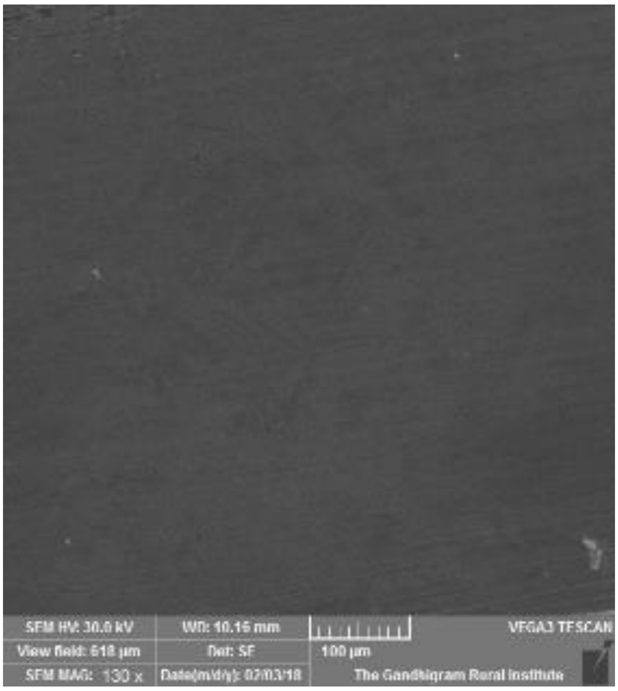


Fig .79: Under 130x

ZIRCONIA ABUTMENT LOADED

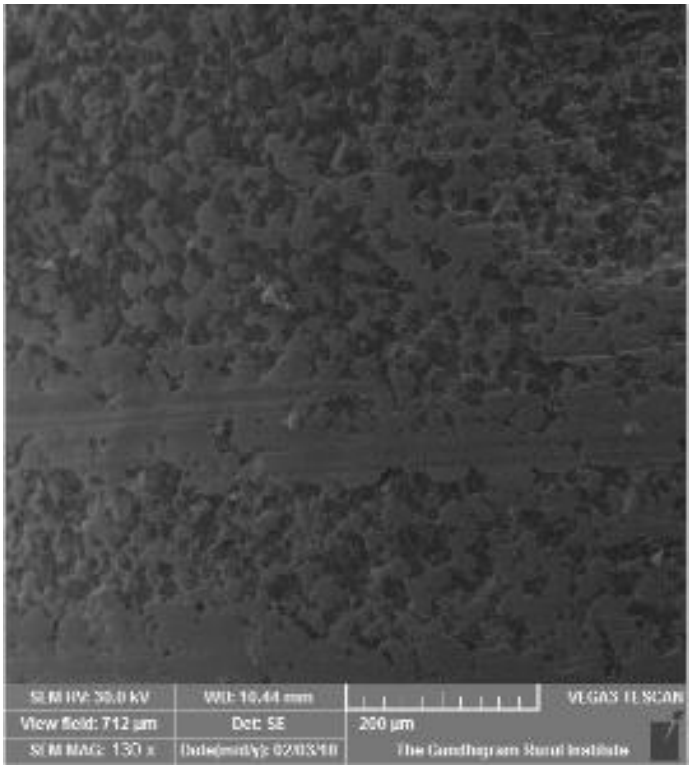


Fig.80: Under 130

TITANIUM ABUTMENT LOADED

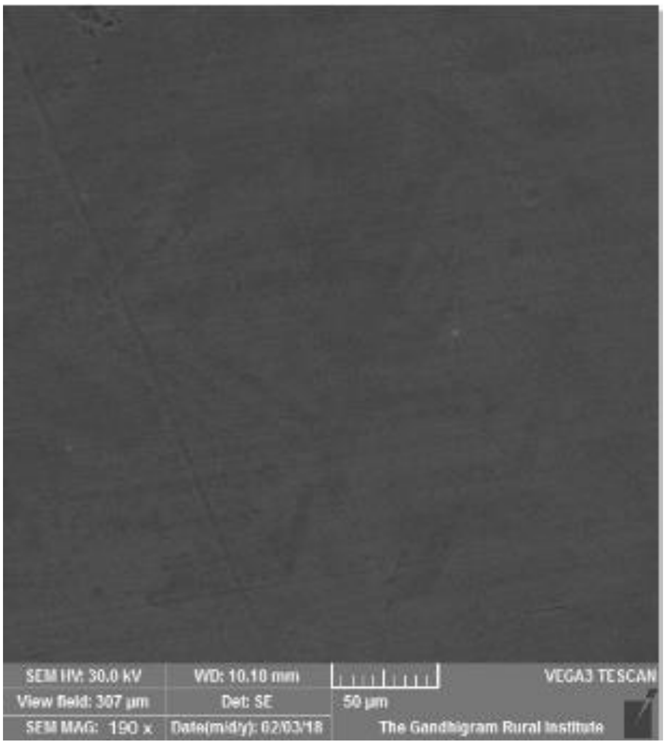


Fig.81: Under 190x

ZIRCONIA ABUTMENT LOADED

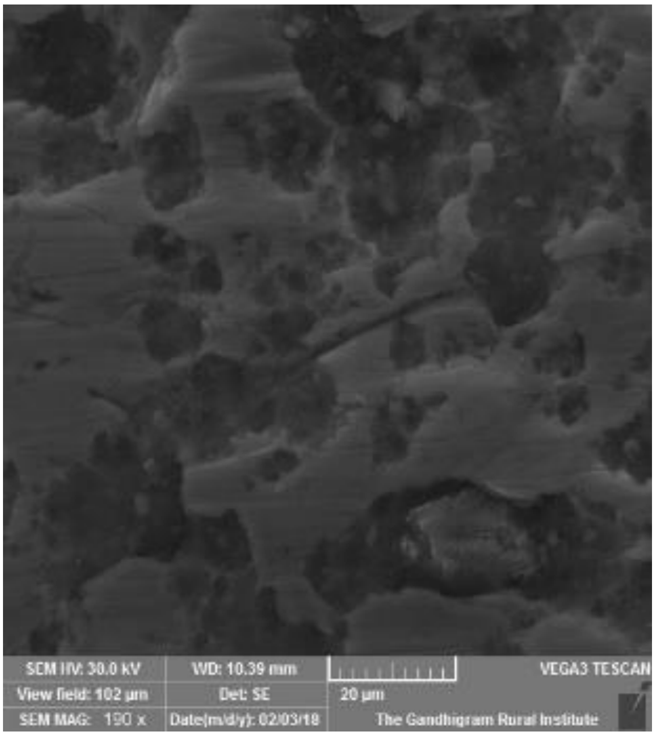


Fig.82: Under 190x

TITANIUM ABUTMENT LOADED

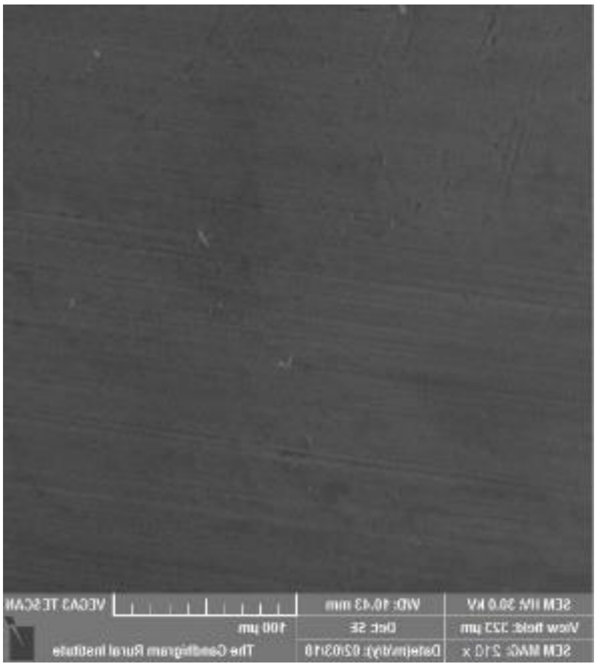


Fig.83: Under 210x

ZIRCONIA ABUTMENT LOADED

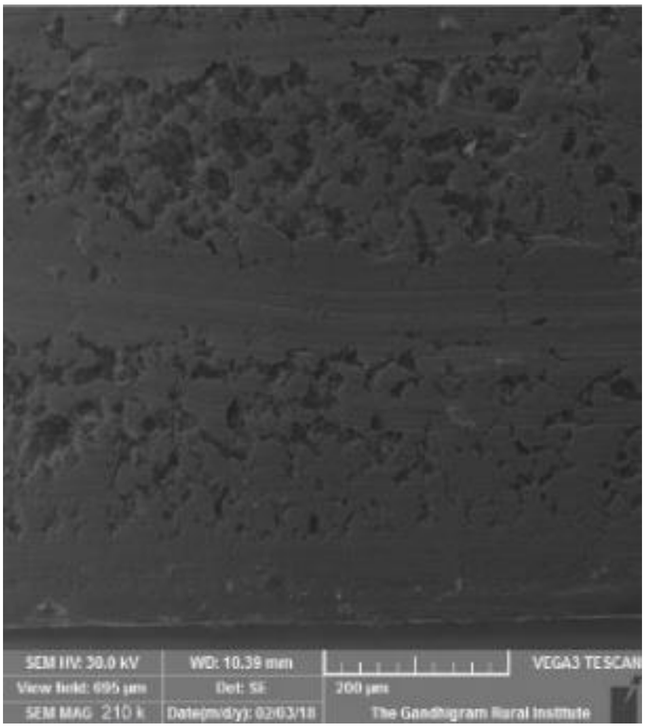


Fig.84: Under 210x

TITANIUM ABUTMENT LOADED

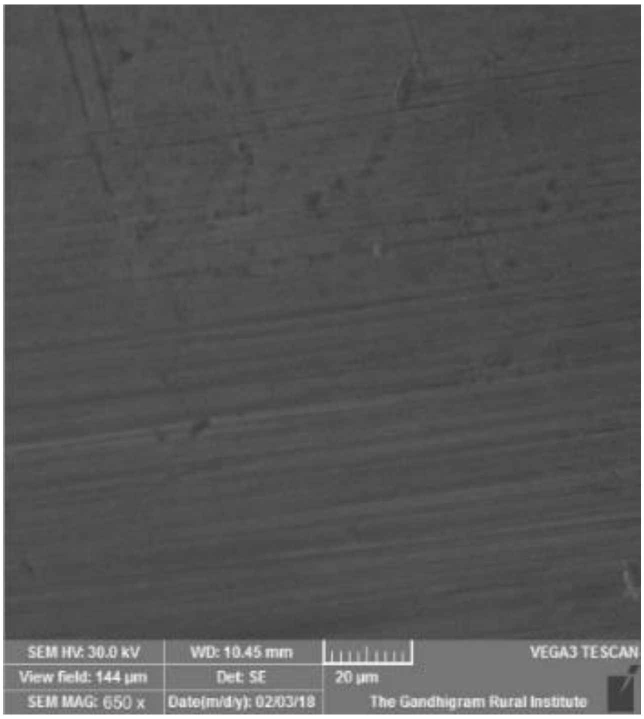


Fig.85: Under 650x

ZIRCONIA ABUTMENT LOADED

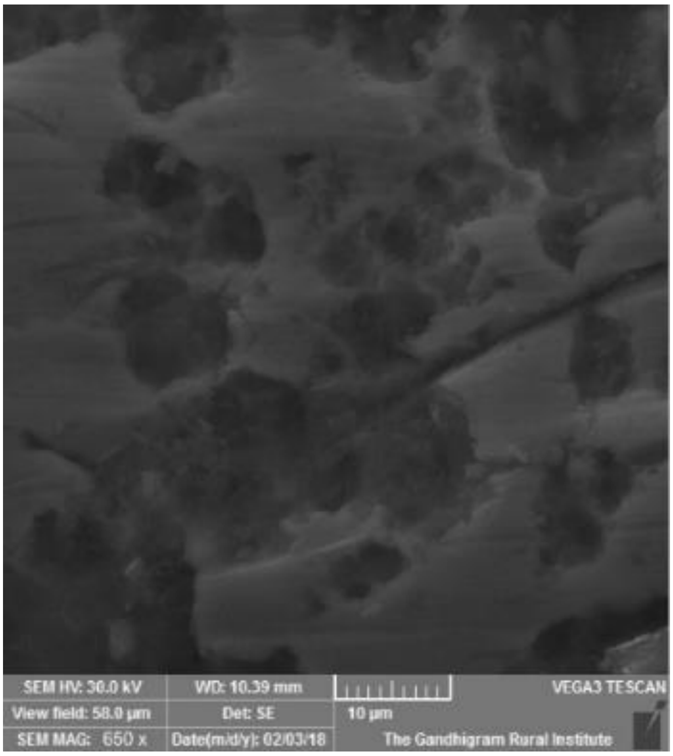


Fig.86: Under 650x

TITANIUM ABUTMENT LOADED

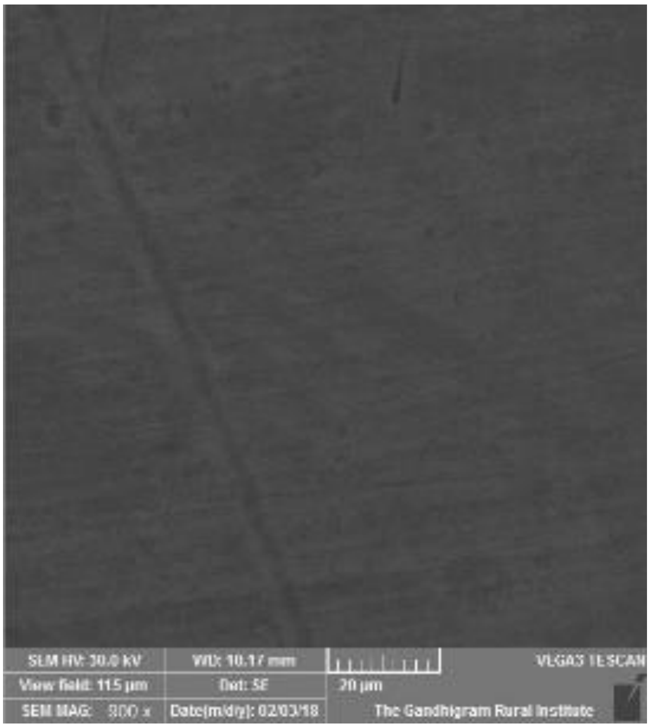


Fig.87: Under900x

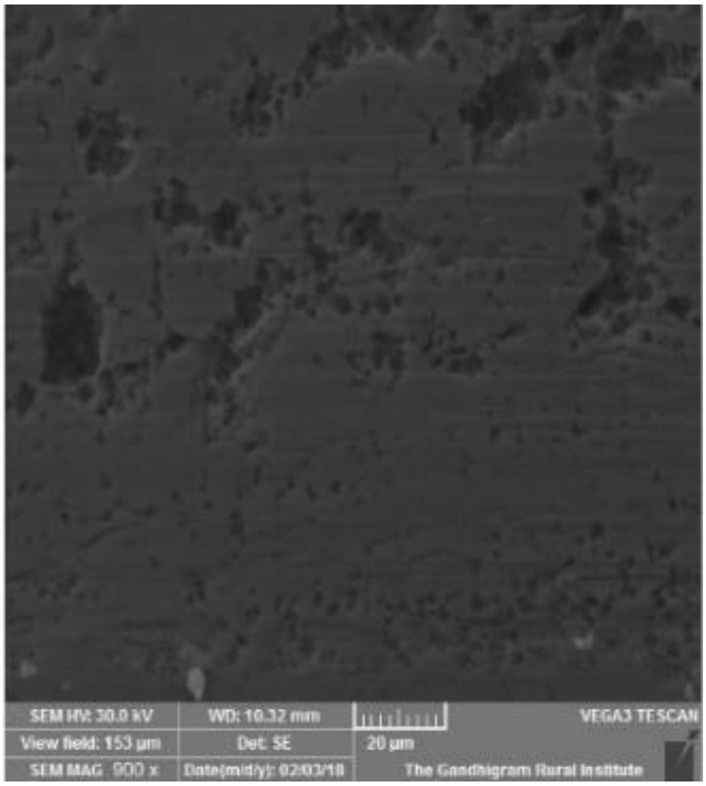


Fig.88: Under 900x

TITANIUM ABUTMENT LOADED

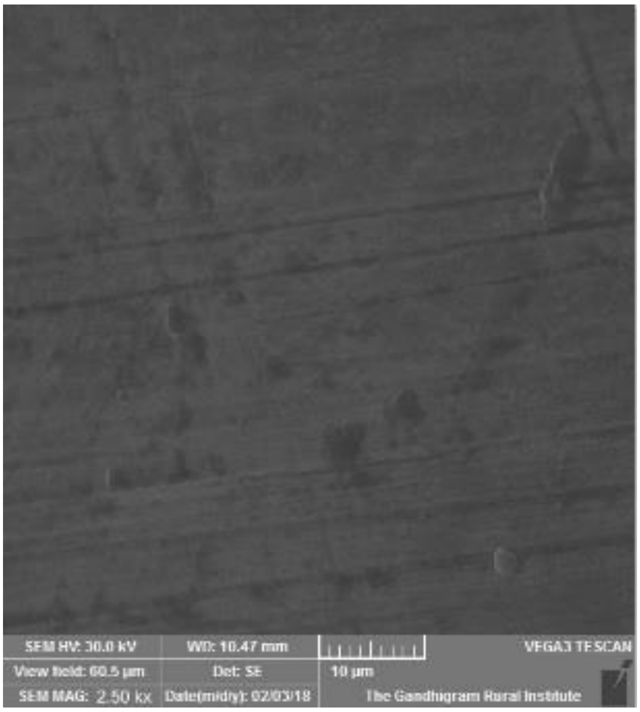


Fig.89: Under 2.50kx

ZIRCONIA ABUTMENT LOADED

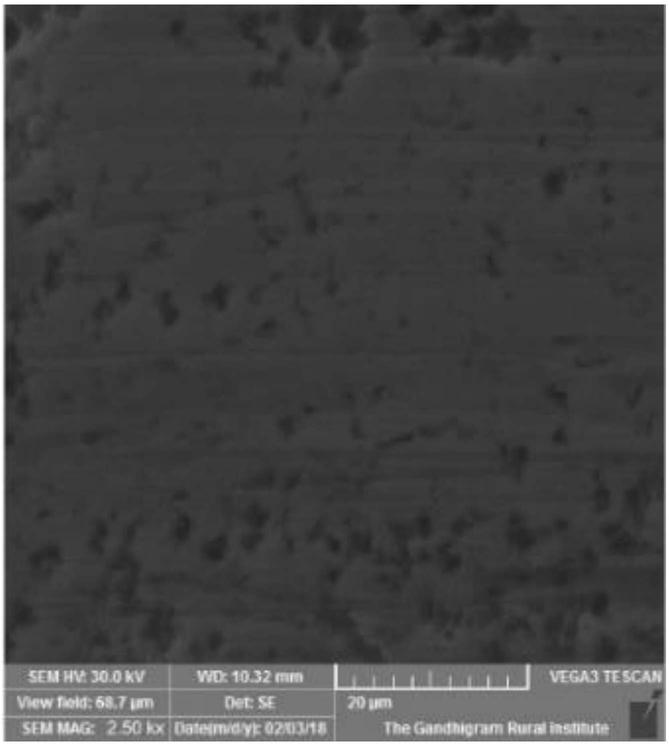


Fig.90: Under 2.50kx

TITANIUM ABUTMENT LOADED

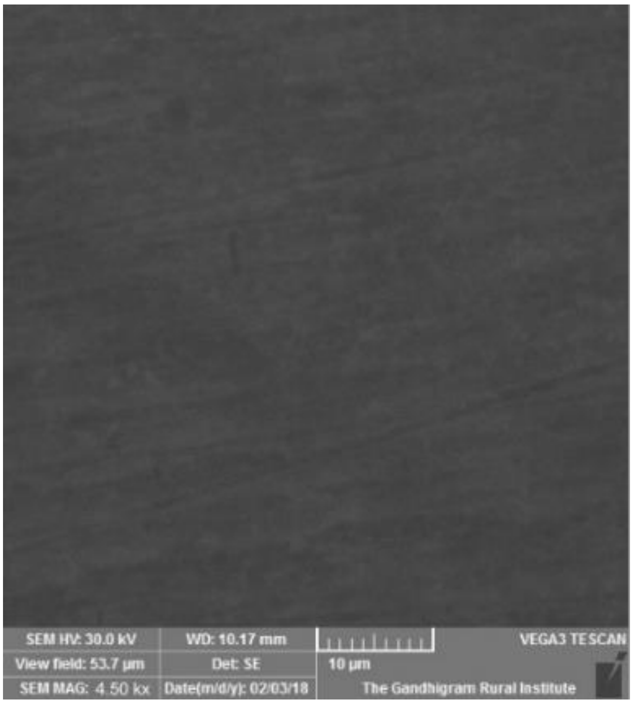


Fig.91: Under 4.50kx

ZIRCONIA ABUTMENT LOADED

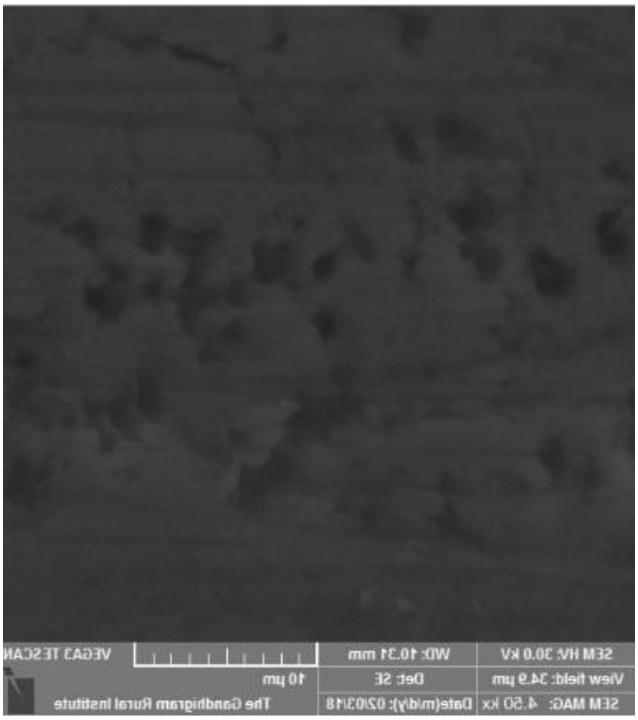


Fig.92: Under 4.50kx

TITANIUM ABUTMENT LOADED

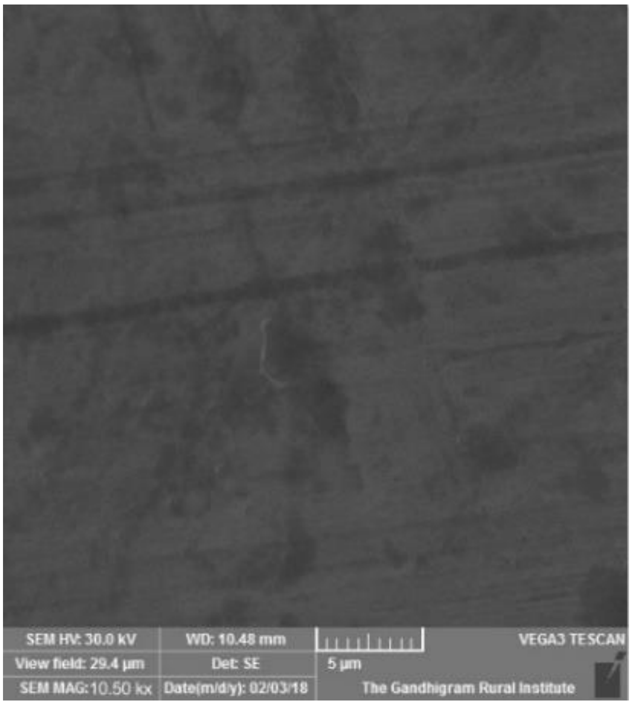


Fig .93: Under 10.50kx

ZIRCONIA ABUTMENT LOADED

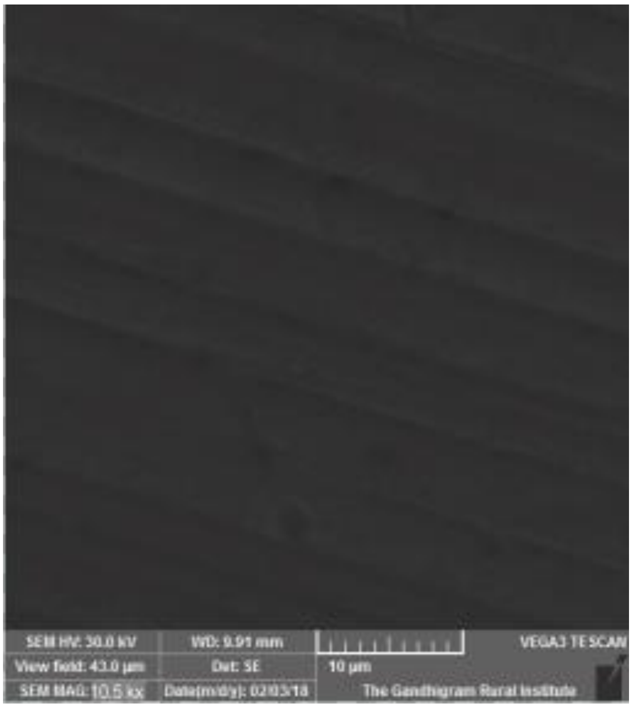
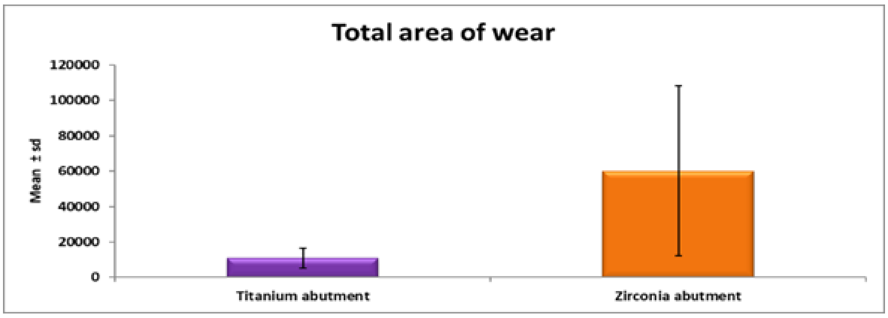


Fig .94: Under 10.50kx

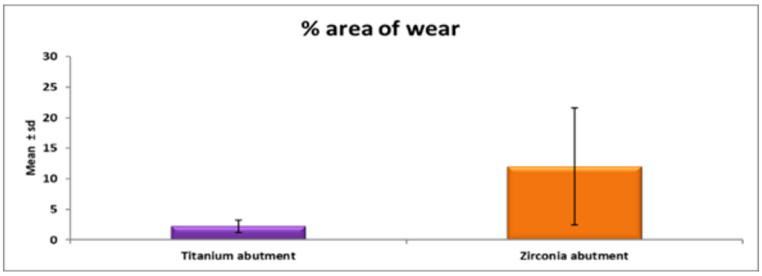
ANNEXURE 3

GRAPH 1: **Comparative evaluation of total area of wear of mean post cyclic loading of Titanium and Zirconia abutments at implant abutment-interface after cyclic loading using ‘t’- test**



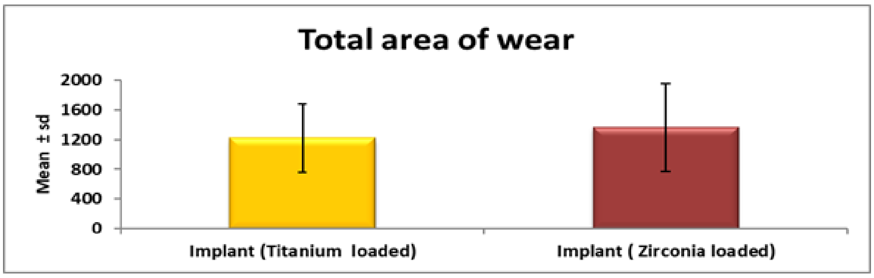
99% significant

GRAPH 2: Comparative evaluation of percentage area of wear of mean post cyclic loading of Titanium and Zirconia abutments at implant- abutment interface after cyclic loading using ‘t’- test



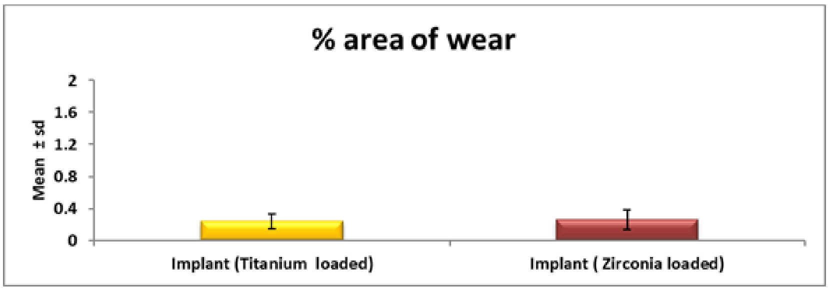
99% significant

GRAPH 3: Comparative evaluation of total area of wear of mean post cyclic loading of Implants connected to Titanium and Zirconia abutments after cyclic loading using 't'- test



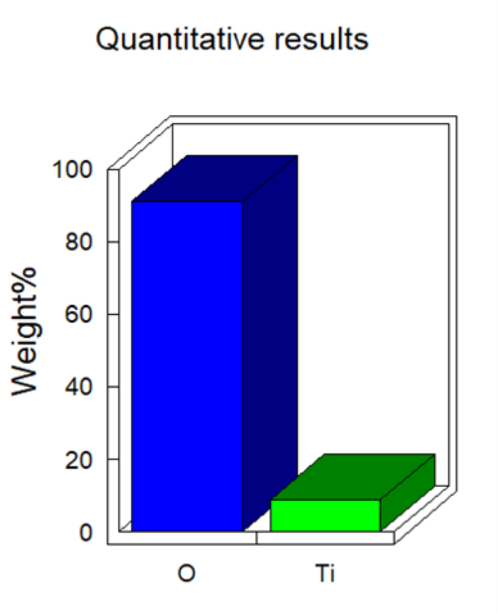
P > 0.001 not significant

GRAPH 4: Comparative evaluation of mean percentage area of wear of mean post cyclic loading of Implants connected to Titanium and Zirconia abutments after cyclic loading using 't'- test

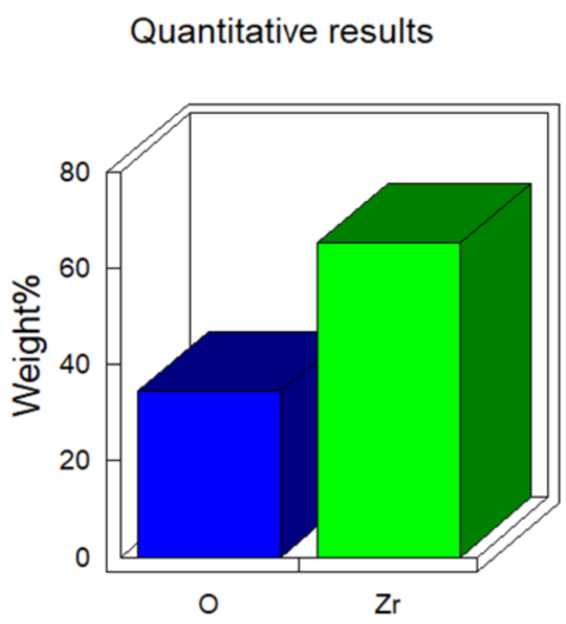


P > 0.001 not significant

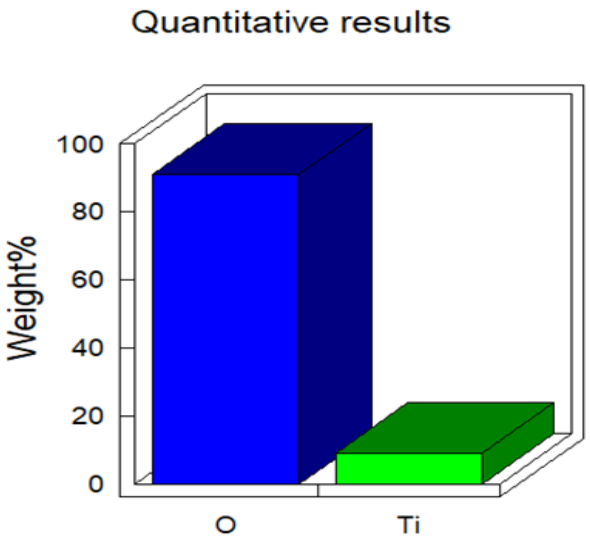
GRAPH 5: Mean value of **dispersed particles of Titanium in Group I test sample (Titanium abutment)**



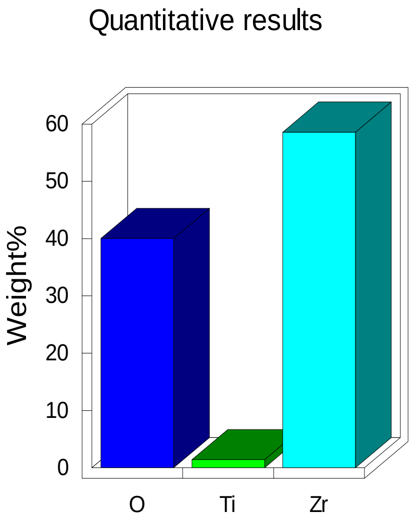
GRAPH 6: **Mean value of dispersed particles of Zirconia in Group II test sample (Zirconia abutment)**



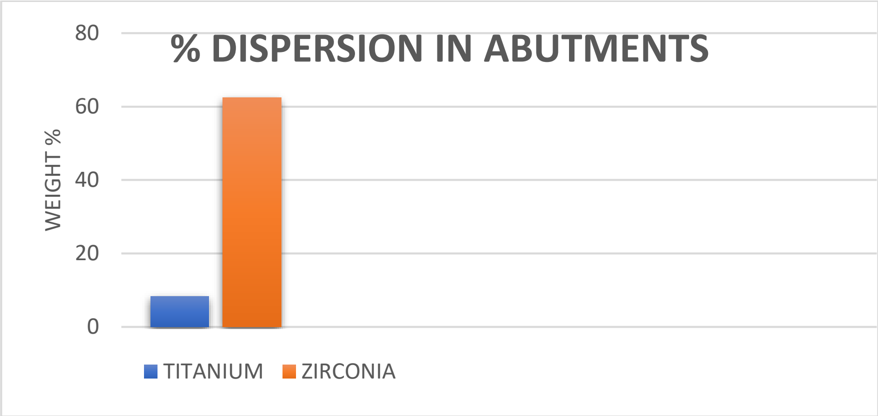
GRAPH 7: Mean value of dispersed particles of Titanium in Implant loaded with Titanium abutments



GRAPH 8: Mean value of dispersed particles of Zirconia in Implant loaded with Zirconia abutments

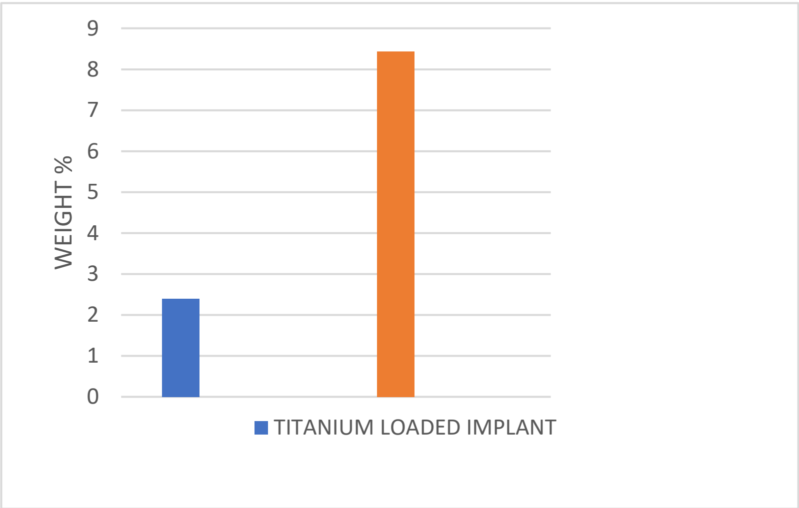


GRAPH 9: **Comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles using 't' -test**



99% Significant

GRAPH 10: **comparative evaluation of Percentage of dispersed particles of Titanium and Zirconia particles in Implant loaded with abutments using 't' -test**



99% Significant

Discussion

DISCUSSION

The present invitro study was conducted to compare the wear resistance and surface changes between the Titanium and Zirconia abutments at the implant-abutment interface when subjected to force transmission in axial direction by cyclic loading.

Replacement of missing teeth with the different available dental implant-abutments in the anterior region has been documented[53,49,42,32,27]. Stock abutments like mirus cone,esthetic cone (Branemark system), made of Titanium, alumina and other metal alloys were used traditionally for many years and its properties are documented[39,6458,23]. It was the only option available to the clinician from the manufacturer, despite its disadvantage of lack of emergence profile[39]. Due to the limitations, castable abutments were used. These abutments have 2 main advantages of good support of soft tissues and favorable margin[39]. Customized implant-abutments are made with metal, ceramics, and composites[12,32,39]. For a long time, cast gold cylinder individual abutments (UCLA abutments) were considered as the state of the art in customized prosthetic solutions.These abutments were indicated in cases of limited vertical restoration space, angulation correction,and in cases demanding embrasure modification[32,23]. However, recently, their use has been rapidly decreasing due to higher pricing[39].Similarly, dental porcelain appeared not to be a proper material for the establishment of reliable soft tissue adherence. Soft tissue recession and bone loss was higher with feldspathic ceramics[39]. Titanium abutments were used successfully for decades due to its strength, resistance to distortion and possibility to be produced as one unit. But the major drawback of Titanium abutment was its dark colour visibility in the esthetically demanding areas like peri implant mucosa with thin gingival bio line. This led to the introduction of tooth coloured ceramic implant-abutments produced in densely sintered alumina[33,32,,5,6o,64,39,58,34]. The first ceramic abutments were the CerAdapt (Nobel BioCare, Gothenberg, Sweden) made of alumina and designed to fit the external hex of Branemark implant system(Andersson et al in 1991) [32,36,12]. Although this product was commercially available more than a decade,its clinical consideration was not documented and published.Some clinicians reported problem of fracture with this alumina abutment in laboratory and clinical procedures.[12,] Since All ceramic abutments cannot be machined to degree of precision as metal abutments[12], there was imprecise fit between abutment and implant leading to screw loosening[12.]This led to introduction of Zireal[TM] Post (Palm Beach Gardens, Florida) by Implant Innovations, made from Zirconia with its apical end with Titanium. Sintering ceramic to Titanium needs to be supported and documented. Otherwise ceramic fracture is likely to be expected[12].

Clinical studies show stable peri- implant mucosa with alumina abutment. But with reported fractures both at laboratory work and during abutment connection[32,60,33]. Due to its shortcomings in its mechanical properties, yttrium oxide-stabilized Zirconia was introduced as an alternative material for implant-abutment. The stress -induced transformation toughening mechanism in Zirconia improves its mechanical strength and reliability [33]. The mechanical and microstructural properties and its biocompatibility have been well documented [12,50,59]. However, the mechanical properties of Zirconia relating to its strength and its pertinence to withstand loading remains unclear[39,50]

Wang et al[60] conducted a research comparing the mechanical properties of Zirconia and Titanium abutments to withstand the oral oblique forces with two levels of marginal bone loss. The study concluded that the Zirconia abutments could withstand physiological occlusal forces in anterior region.

Many studies[58] show less microleakage in static loading conditions and increased microleakage in dynamic loading conditions. Almost all the studies show that there was some amount of microleakage at abutment implant interface which was eventually due to screw loosening

De Jesus Tavarez [23]concluded in a study that the cyclic loading and implant-abutment used influenced on the vertical misfit at the implant-abutment interface. The cyclic loading increased the vertical misfit of premachined UCLA abutments for external hex abutments.

Stimmelmayr[57] conducted an invitro study to analyse the wear at interface between the Titanium and Zirconia abutments when connected to internal hex Titanium implants.6 implants were secured in resin blocks and connected to 3 Titanium and Zirconia abutments respectively. The samples were loaded in cyclic fatigue testing machine at an angulation of 30 degree for 1,200,000 cycles at a frequency of 1.2 Hz with a force of 100N.The samples underwent SEM and CT micrographs pre and post loading. It was found high wear of Titanium implants connected to Zirconia abutments.

The occlusal forces in the posterior region showed higher values than the anterior[22,30,52]. The dental abutments should withstand the occlusal forces in axial direction and the surface changes at the implant-abutment interface is taken into consideration to check for its longevity in the intra oral condition. Mechanical testing of implants and their component has been used to greatly to decrease the experiment time that is needed to simulate the long-term usage properties intra orally. The samples were subjected to cyclic loading to simulate the intra oral occlusal forces at regular intervals. The samples subjected to repeated force transmission in axial direction showed surface characteristics changes. This invitro study simulated the compressive occlusal forces acting on the posterior region corresponding to molar region of the mandible to evaluate the surface characteristic changes happening in the implant-abutment interface for a given period.

Yuzugullu et al[64] concluded with the dynamic loading study and the results showed no significance at the implant-abutment interface regarding microgap between the abutments of aluminumoxide, zirconium oxide and Titanium groups. But for the palatinal surface comparison, Titanium abutment group showed slightly increased microgap compared to Zirconia and aluminum oxide abutments.

Almeida[4]and colleagues observed the wear of seating platform of externally hexed Titanium implants when connected to Zirconia abutments was more compared to Titanium abutments. The samples underwent thermocycling and surface topography was measured before and after mechanical loading (1.2× 106 cycles;88.8N;4Hz). The samples were subjected to scanning electron microscope and the results revealed the mild wear in implant at some vertices of hex when connected to Zirconia abutments. But the results were not statistically significant.

In the present invitro study, the influence of force transmission in the axial direction at the implant-abutment interface between the Titanium and Zirconia abutments were evaluated. The implants (MIS Lance internal hex standard platform) were placed in the fibre reinforced resin block. This resin block has modulus of elasticity similar that of alveolar bone[25,48,56], which replicated the implant's behavior in the mandible. Two resin blocks of 25mm diameter and 16mm height were sectioned using machining lathe. A customized jig was fabricated with iron measuring of 13cm× 4.5cm×0.8cm in dimensions in the industrial lathe. 3mm parallel holes were drilled in the resin blocks to attach to the customized jig. Two implants, one for Titanium samples and one for Zirconia samples were placed in the fibre reinforced resin block by implant osteotomy procedure following classical protocol. The implants were placed and secured in the resin block using a torque wrench/ratchet. The tapered design of the implant enabled the stability within the fibre resin block. The final tightening torque was 45 N/cm. It was confirmed that the implants had primary stability and no movement of the implants was observed in the resin block. The Titanium abutments and Zirconia abutments were connected to the implants and the abutment screw was torqued to 25N/cm as per manufacturer's recommendation. Prior connecting the implants to the abutments, digital photographs were made for the Titanium and Zirconia abutments for it to serve as the baseline image. The abutments were also subjected to scanning electron microscope to study the surface character.

The samples were bolted to a loading jig that holded and positioned the implant-abutment assembly to the loading machine. The loading jig is bolted to the loading platform at an angle of 90 degree rise from the horizontal plane. The angulation was used to perform the compressive axial force transmission on the occlusal surfaces of the mandibular posterior teeth[25]. The stylus of the loading machine was positioned to the centre of the abutmentloaded and was subjected to cyclic loading[41,4,57,23,16,61,13,5]. A sinusoidal waveform at 2Hz of load up to 200 N for a period of 25 hours (1500mins) simulating 1,80,000 cycles which was approximately 4 months of intra oral functioning. This was repeated for all the twenty samples. At the completion of the cyclic loading period, each test samples were subjected to visual and tactile examination for any deformity and screw loosening. No abutment screw loosening, implant loosening and fracture of any tested samples (Titanium abutment, Zirconia abutment, implant, abutment screw) was evident after cyclic loading. Visual examination of the post loaded Zirconia abutments showed concentric greyish bands around the abutment that seats over the implant at the implant-abutment interface. No such rings were evident in Titanium abutment samples. Post loading SEM analysis was carried out for all the samples.

Comparing the SEM images, a clear difference in wear and surface characteristics of Titanium abutments and Zirconia abutments were observed. The Zirconia abutments showed greater wear than the Titanium abutments.[58,12,60]. The SEM images were quantitatively converted through Image Analysis Software. The results were tabulated, and statistical analysis done.

Energy Dispersive X ray particle Analysis was carried out to examine the presence of suspended particles. EDX analysis involved the qualitative and quantitative analysis of the suspended particles. Qualitative analysis involved the identification of the elements present and is a prerequisite for quantitative analysis. EDAX involves the dispersed X-rays which are electromagnetic radiation containing photons. Latest detector called as silicone-drift detector (SDDs) is used to detect the X-ray[62,9]. These detectors are placed under an angle, close to the sample and measures the energy of the incoming photons from X-rays. The EDAX of the Titanium abutment showed mild dispersion of Titanium particles over the implant-abutment interface surface. Whereas, the Zirconia abutment showed increased range of Zirconia particles on the implant -abutment interface surface. The same Zirconia particle concentration was higher in the implants loaded with Zirconia abutments than the implants connected to Titanium abutments.

The EDAX results clearly revealed that there is increased wear at the Zirconia abutment when subjected to axial forces when compared to Titanium abutment. This is defined in Tribology (Science and Technology of interacting surfaces in relative motion) aswear due to loss of material from a surface by means of some mechanical action and oscillatory motion between two solid surfaces in contact known as Fretting[12,4,50]. One possible reason for abrasiveness of Zirconia is its hardness property. The hardness of a material is directly correlated with its wear behavior[12]. Knoop hardness value of Zirconia measures 1200Kg/mm^2 and for Titanium it measures 250 Kg/mm^2.Zirconia being five times harder than Titanium, abraded readily than Titanium when subjected to axial forces[4].The other reason can be due to the difference in modulus of elasticity of two different materials which are being connected[57]. If the implant and abutment are of same material (Titanium), the deformation energy is equally distributed. But not so in the implant connected to Zirconia abutment.

In this in-vitro study, the presence of Zirconia particles with statistically significant values were observed at the implant-abutment interface and the internal hex of the implants. This is a matter of concern, as the Zirconia particles can dissipate to the surrounding peri-implant tissue. No studies have mentioned about the tissue reaction to dispersed Zirconia particles and it is not clear about its presence in the extracellular fluid such as saliva, blood and urine. Also, the concentric greyish bands at the interface is of concern in thin gingival line[12,4,57].

Conclusion

CONCLUSION

The following conclusions were drawn based on the results obtained in the present in vitro study, which was conducted to compare the wear resistance between the Titanium and Zirconia abutment at the implant- abutment interface after force transmission by cyclic loading.

1. On comparison, the mean area of wear between the Titanium (10691.00 μm^2) and Zirconia abutments (60076.38μm^2) at the implant- abutment interface post-cyclic loading was found to be higher for Zirconia abutment (12.01%) than the Titanium abutments (2.22%) which was statistically significant $p < 0.01$

2. On comparison, the area of wear between the implants loaded with Titanium(1222.54μm^2) and Zirconia(1364.37μm^2) abutments at the internal hex was found to be statistically not significant $p > 0.05$

3. On comparative evaluation of percentageof EnergyDispersive X ray particles of Group II (62.42%) test samples at the implant - abutment interface was higher than Group I test (8.36%) samples and it was statistically significant (p value < 0.001)

4. On comparative evaluation of Percentage of Energy Dispersive X ray of particles of Titanium (12.09%) and Zirconia (56.84%) particles in Implant loaded with abutments at the level of internal hex was found to be higher for Zirconia abutments loaded implant and was statistically significant (p value < 0.001)

Within the limitations of this *in vitro*study, the following conclusion can be drawn

GROUP I (Titanium abutment) shows higher wear resistance than GROUP II (Zirconia abutment)

GROUP I > GROUP II

1. The wear of the Zirconia abutment at the implant -abutment interface is much higher than the Titanium abutment when connected to the Titanium Implant with statistical significance.

2. The wear of the Implant at the implant-abutment interface was high when connected to Zirconia abutment than the Titanium abutment but not statistically significant.

3. The suspended particles at the Implant -abutment interface shows higher concentrations of Zirconia abutment than the Titanium abutment with statistical significance.

4. The Implant connected to Zirconia abutment shows high dispersion of Zirconia particles when compared to Implant connected to Titanium abutment at the level of internal hex with statistical significance.

CLINICAL RELEVANCE

Zirconia is a material of choice presently in the esthetic demanding zone and the force transmission in the tangential direction is well tolerated[43,50]. But, when the Zirconia abutments were subjected to axial loading (cyclic loading), the change in the surface characteristic (wear resistance) is a matter of concern from mechanical point of view. The dispersion of Zirconia particles was higher (7 times), and it is statistically significant when compared to Titanium abutment. This was observed both at the implant- abutment interface and at the internal hex of the implant. The presence of Zirconia particles in clinical situation may have its presence around the peri-implant tissue, its migration to the neighbouring soft tissue, saliva and crevicular fluid is inevitable. And there are not many studies about the effect of dispersed Zirconia particles on soft tissue and its traces in the extracellular fluids such as saliva, blood and urine. Hence further studies are warranted to assess the effect of the dispersed Zirconia particles on soft tissue and its traces in the saliva, blood and urine clinically.

Summary

SUMMARY

The present *in vitro* study was conducted to compare and evaluate the wear resistance between the Titanium and Zirconia abutment at the implant - abutment interface after force transmission through cyclic loading and subjected to Scanning Electron Microscope to measure the surface characteristic changes due to wear. The photomicrograph images of the Scanning Electron Microscope were converted to its equivalent quantitative values by Image Analysis Software. The samples underwent Energy Dispersive X Ray Analysis to evaluate the dispersed particles at the implant - abutment interface.

To compare and evaluate the surface characteristic changes due to wear at the implant- abutment interface, total of 10 Titanium abutment samples (Group I) and 10 Zirconia abutment samples (Group II) were obtained. Two Titanium regular platform MIS (3.75mm×10mm) internal hexagon connection implants were used to connect the Group I abutments and Group II abutments separately. Samples underwent Scanning Electron Microscope and EDAX prior to cyclicloading to record the surface character of samples at the implant abutment interface. Fibre reinforced epoxy resin rod (NEMA G10) was used to place the implants. The fibre reinforced resin rod has almost the same modulus of elasticity as the trabecular bone. It was sectioned into 16mm thickness and 25mm diameter blocks. 3mm parallel holes were drilled in the blocks.A customized jig was fabricated to orient the samples in the cyclic loading machine. The fibre reinforced epoxy resin blocks were attached to the customized jig through the 3mm parallel holes. Implants were placed in the centre of the fibre reinforced epoxy resin blocks by classical drilling protocol. Implants were final torqued to 45N/cm with torque wrench/ ratchet. The abutments were connected to the implant and torqued to 25N/cm according to manufacturer's recommendation.

The jig along with the mounted implant abutment assembly was placed in the cyclic loading machine. Each sample underwent cyclic loading in the axial direction with loads up to 200N for 1,80,000 cycles at a frequency of 2 Hz to simulate 4 months of intra oral function.

The abutments were checked for screw loosening. No screw loosening was observed in any of the abutment. The abutments were removed using the hex driver and torque wrench/ ratchet. The samples were subjected to Scanning Electron Microscope to assess the surface characteristic of the samples post cyclic loading changes due to wear at the implant - abutment interface. The photomicrographs of the Scanning Electron Microscope obtained were converted to quantitative values by Image Analysis Software. Visual examination of the post cyclic loaded Zirconia abutments showed greyish concentric rings at the implant - abutment interface. To evaluate the concentric rings in the Zirconia abutments, and the dispersed particles at the implant - abutment interface, Energy Dispersive X Ray Analysis was done for all the samples (Group I and Group II) including the two implants connected to abutments. The results obtained were tabulated and statistically analyzed through ‘t’ test and Levene’s test.

The Scanning Electron Microscope images showed more uniform surfaces for Group I samples and more roughened surfaces for Group II samples. The Scanning Electron Microscope images of implant connected to Group II samples shows slightly roughened surface than the implant connected to Group I samples. This result was correlated with the quantitative data obtained from the Image Analysis Software. On correlating the SEM and Image Analysis results, Zirconia abutment (Group II) showed more changes in the surface character at the implant - abutment interface compared to Titanium abutments (Group I) and it was statistically significant. On examining the implants connected to the abutments, the surface of the implants connected to the Zirconia abutments showed slight increased wear at the level of internal hex than the implant connected to Titanium abutment without statistical significance.

The EDAX results revealed the dispersion of particles from the Zirconia abutment (Group II) was higher when compared to Titanium abutments (Group I) at the implant - abutment interface and it was statistically significant. On comparing the EDAX results of the implants connected to Zirconia and Titanium abutments at the level of internal hex, it revealed higher concentration of Zirconia particles than the Titanium particles which was statistically significant.

In the present study, on correlating the SEM, Image Analysis Results and EDAX, it reveals that the Zirconia abutments showed statistically significant increased wear at the implant -abutment interface and dispersion of Zirconia particles was high when subjected to axial occlusal loading when compared to Titanium abutments. The suspended particles in the implant also showed statistically significant higher concentration of Zirconia particles at the internal hex. The comparative wear percentage of implants connected showed values which are not statistically significant. This showed the Zirconia abutments are less wear resistant than the Titanium abutments.

The Zirconia abutments are a significant replacement of Titanium abutments in the anterior region (esthetically demanding areas), where the occlusal forces are moderate. But for the posterior region, where the occlusal forces are higher than the anterior region, the usage of Zirconia abutment is to be considered with caution due to its low wear resistance and dispersion of particles at the implant - abutment interface.

The concentric greyish rings formed on the Zirconia abutment at the implant - abutment interface is of concern in the clinical usage. Further long standing multicenter clinical trials are needed to substantiate the usage of Zirconia abutment in posterior region.

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