

# A Comparative Assessment of Bite Pressure between Implant Prosthesis and Natural Teeth: An *In vivo* Study

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## Abstract

**Aim of the Study:** This study aims to evaluate and compare bite pressure among individuals with implant prosthesis on one side and natural dentition on the contralateral side in mandibular 1<sup>st</sup> molar region using NUPAI bite scan system.

**Materials and Methods:** A total of 30 subjects (15 in which implant prosthesis on the right side and 15 in which implant prosthesis on the left side) with implant prosthesis on the one side and natural dentition on the contralateral side participated in the study. The bite pressure was measured at the first molar area on both the sides using NUPAI bite scan.

**Results:** Maximum bite pressure, average bite pressure, and the amount of the pressed area were found to be more on the natural dentition side in comparison to the side with implant prosthesis. Average pressure on natural teeth was 25.33 MPa and on implant prosthesis 21.27 MPa.

**Conclusion:** The present study concludes that the measured bite pressure at the natural dentition side is found to be higher than those at the fabricated implant prosthesis side. *P*-value for average bite pressure is 0.033, which is significant ( $P < 0.05$ ).

**Key words:** Bite pressure, Bite sensor, Group function occlusion, Screw-retained implant prosthesis

## INTRODUCTION

Determination of individual bite force level in dentistry has been widely used to understand the mechanics of mastication for the evaluation of the therapeutic effects of prosthetic devices and to provide reference values for studies on the biomechanics of prosthetic devices. The measurement of bite force is useful in evaluating muscle function and is also an adjunct in assessing the performance of prosthesis. Measurements related to bite force are difficult to detect and the reliability of the result depends on large number of

factors, such as gender, age, craniofacial morphology, occlusal factors, presence of pain, and temporomandibular disorder. Apart from these physiological factors, recording devices and techniques play major role and are important factors in bite pressure measurement. To evaluate bite pressure, various techniques and devices are utilized including portable hydraulic pressure gauges, the bite fork, force sensing resistors, strain gauge transducers, pressurized rubber tube, foil transducers, pressure-sensitive sheets, and the gnathodynamometer.<sup>[1]</sup>

The fitness of the masticatory framework relies mostly on alignment and occlusion of dentition. Improper occlusal contacts and inappropriate head postures are considered to be the main causes for the start of pain in the temporomandibular joint (TMJ) later followed by TMJ disorders.<sup>[2]</sup> Bone is the ultimate bearer of the occlusal load as dental implants are placed. Maximum bite force generated by patients is not uniform. Posterior jaw occlusal

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biting load is about 3 times more than that of anterior biting load. Bone loss around implant and failure of fixture can be due to overloaded implant prosthesis by patients' biting force. When planning dental implant treatment, bite force measurement may be an important parameter. Luxation of the fixture and subsequent loss of osseointegration may occur in patients generating extreme biting loads. Long-term successful outcome even with poor anatomical bone qualities can be seen in patients with low biting force. There is an increased risk for late component fracture or implant failure in patients with a high bite force.<sup>[3]</sup>

It has been documented that human mean maximum bite force is 738 N. Significant values were found for gender related mean maximum bite force, whereas the correlation coefficients for age, stature, weight, and body type were found to be low. Raadsheer *et al.* (1996) reported similar results and average values of the maximal voluntary bite forces in men were 545.7 N, and in females, it was reported 383.6 N.<sup>[4,5]</sup> In a dentate person, the average force has been measured 150–250 psi in the first molar region.<sup>[6]</sup> Forces of mastication are not constant in all the individuals and vary person to person according to these studies.

NUPAI bite scan enables anyone to measure pressure easily, just by inserting sensor between two surfaces. Measures pressure by color density. Not just force at a single location, it measures the distribution of it. No power source required just cut and fit any dimensions. Computer digital reading of sensor by scanner that convert pressure density dots into quantity values. Precise measurement of bite pressure, pressure distribution, and pressure balance can be done with the help of prescale film. Pressurized area of film will change its color to red on application of pressure and the color density varies according to the various pressure levels. The present study compares the biting pressure within the same patient on the mandible where one side has natural dentition and the contralateral side has been restored with an implant prosthesis using NUPAI bite scan system.

## MATERIALS AND METHODS

The present study is an *in vivo* study which was conducted in the Department of Prosthodontics and Crown and Bridge and SN Enterprise (NUPAI bite Scan), Delhi. Thirty patients were selected for the study.

### Inclusion Criteria

The following criteria were included in the study:

- Successfully osseointegrated single posterior dental implant prosthesis with respect to any of the mandibular 1<sup>st</sup> molar region in occlusion with natural dentition

- Sound natural mandibular 1<sup>st</sup> molar tooth on contralateral arch in occlusion with natural dentition
- Proper neuromuscular coordination.

### Exclusion Criteria

The following criteria were excluded from the study:

- Temporomandibular disorders
- Implant prosthesis other than mandibular 1<sup>st</sup> molar
- More than 1 implant prosthesis
- History of bruxism and traumatic occlusion
- Faulty implant prosthesis
- Oral infection
- Soreness
- Ulceration
- Inflammation.

### Materials

1. Articulating paper (Bausch, Germany)
2. NUPAI bite sheets (Fuji, Tokyo, Japan)
3. Bite sheet holder (NUPAI, S.N Enterprise, Delhi [Figure 1]).

### Methodology

A thorough case history of the patient was taken. Clinical examination of the patient was done to meet the inclusion criteria and rule out the exclusion criteria. Thirty patients were divided into two groups: Group 1: Having implant prosthesis on the right side and Group 2: Having implant prosthesis on the left side.

In the 1<sup>st</sup> appointment, occlusion of the implant prosthesis was checked and health of implant and peri-implant tissues was evaluated with the help of orthopantomogram [Figure 2]. As natural teeth are periodontally sound and embedded in bone while implant prosthesis has no periodontal ligaments. There is difference in vertical movement of the natural tooth and implant prosthesis. The patient is asked to bite into centric relation with a very light force on thin articulating paper to evaluate occlusal contacts. The implant crown should have



Figure 1: Holder with sensor (bite sheet)

no contact in light biting force. Any contact with the implant prosthesis is removed. Then, the patient was asked to apply greater occlusal force to the articulating paper as equal to normal food chew force so that equal contact of implant crown and natural teeth occurs. This “timed” contact will account for the mobility differences between the teeth and implant prosthesis.

In the 2<sup>nd</sup> appointment, the bite of the patient was taken. The patient was asked to sit straight and the position of the head was adjusted so that it was straight. The bite sheet within a thin plastic pouch [Figure 1] to prevent saliva contamination was inserted in the holder so that the shiny

surface of the sheet would face downward. The sheet and holder were inserted in the patient’s mouth [Figure 3]. The patient was asked to bite a single time over the bite sheet with maximum force. The red markings [Figure 4] on the sheet as a result obtained were sent for NUPAI bite scan analysis. Figures 5–13 depict the different stages of the *in vivo* study.

### Statistical Analysis

The data were entered into a Microsoft Excel spreadsheet and imported into Statistical Package for the Social Sciences (SPSS) version 22 for statistical analysis. Data were present

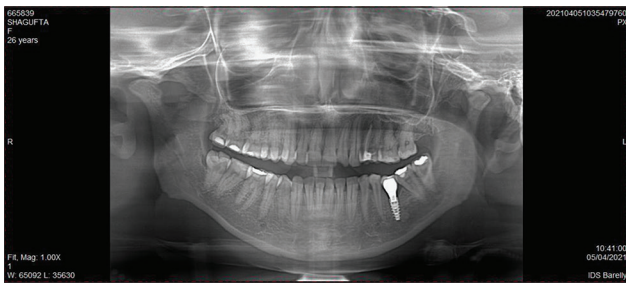


Figure 2: Post-operative orthopantomogram



Figure 3: Patient biting on sensor



Figure 4: Sensors with bite pressure recorded (red markings)



Figure 5: Centric occlusion



Figure 6: Protrusive occlusion



Figure 7: Left lateral: Protrusive occlusion



Figure 8: Right lateral: Protrusive occlusion



Figure 11: Left occlusion view: Centric relation



Figure 9: Maxillary occlusal view



Figure 12: Right occlusion view: Centric relation



Figure 10: Mandibular occlusal view

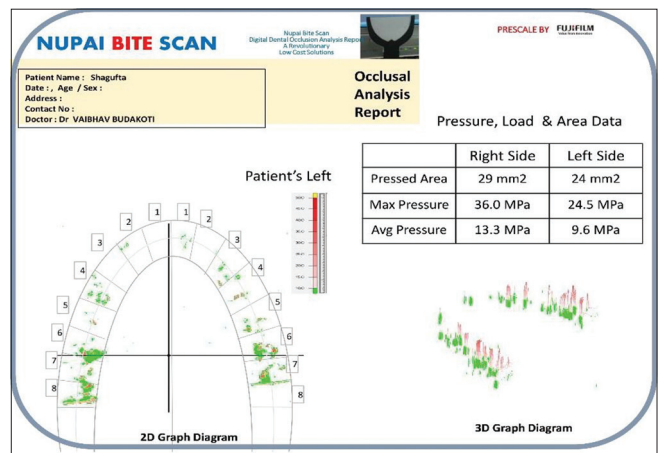


Figure 13: Result showing right and left side bite pressure values

in mean and standard deviation. Independent *t*-test was performed to find significant difference in different variables in group. *P* = 0.05 was considered as a baseline. Tables 1-10 are the collected data (patients) and statistical analysis tables.

## OBSERVATION AND RESULTS

Amount of pressed area at right angle implant prosthesis was  $26.27 \pm 11.83$  and in contralateral side natural teeth was  $30.27 \pm 11.83$ . Mean amount of the pressed area was

**Table 1: Group 1 – Mandibular pressure record: Implant prosthesis on the right side and contralateral side natural teeth**

Particulars	Pressed area (mm <sup>2</sup> )		Maximum pressure (MPa)		Average pressure (MPa)	
	Natural	Implant	Natural	Implant	Natural	Implant
Subject 1	28	22	33.8	31.3	11.3	7.0
Subject 2	40	37	35	33.8	9.8	7.8
Subject 3	48	43	31.3	33.3	10.5	7.5
Subject 4	24	22	40.3	38	13	11.5
Subject 5	54	46	39	37.8	11.3	10.5
Subject 6	30	26	33.8	30.5	12.5	10.0
Subject 7	17	14	35	31.8	10.5	10.3
Subject 8	28	25	32	31	13	12
Subject 9	23	20	40	36.7	13	11.5
Subject 10	29	24	34	30	10	8.7
Subject 11	18	16	32	28	10.5	10
Subject 12	21	16	28	25	12	9.9
Subject 13	48	36	34	30	14.5	12
Subject 14	18	22	36	27	11	12.5
Subject 15	28	25	31	30	13	11

**Table 2: Group 2 – Mandibular pressure record: Implant prosthesis on the left side and contralateral side natural teeth**

Particulars	Pressed area (mm <sup>2</sup> )		Maximum pressure (MPa)		Average pressure (MPa)	
	Natural	Implant	Natural	Implant	Natural	Implant
Subject 1	22	20	30	23.3	6.5	5.3
Subject 2	39	30	36	34.5	11.3	10.3
Subject 3	31	24	40	37.5	12.5	10
Subject 4	28	26	40.5	38.8	13.5	11.2
Subject 5	29	20	35.5	29.5	9.3	8.5
Subject 6	22	19	37	33.3	12	11
Subject 7	18	16	33.8	31.0	12.3	12
Subject 8	23	21	41	36	14	12.5
Subject 9	16	14	32	28	10	9
Subject 10	20	17	37	30	13.5	11
Subject 11	34	27	39.6	34	12	10
Subject 12	29	28	32	36	11.7	11.9
Subject 13	22	18	27	24	10.8	8.3
Subject 14	26	22	40	36	13	10.5
Subject 15	21	17	33	29	12	10

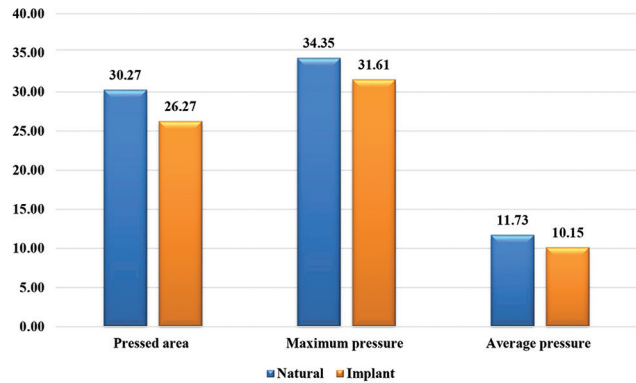
found more in contralateral side natural teeth as compared to implant prosthesis and there was a significant difference in mean amount of the pressed area in between right side implant prostheses and contralateral natural teeth .

Maximum bite pressure at right side implant prosthesis was 31.61 ± 3.78 and in contralateral side natural teeth was 34.35 ± 3.44. Maximum bite pressure was found more in contralateral side natural teeth as compare to implant prosthesis and there was significant difference in maximum bite pressure in between right-side implant prosthesis and contralateral side natural teeth.

Average bite pressure at right side implant prosthesis was 10.15 ± 1.72 and in contralateral side natural teeth was

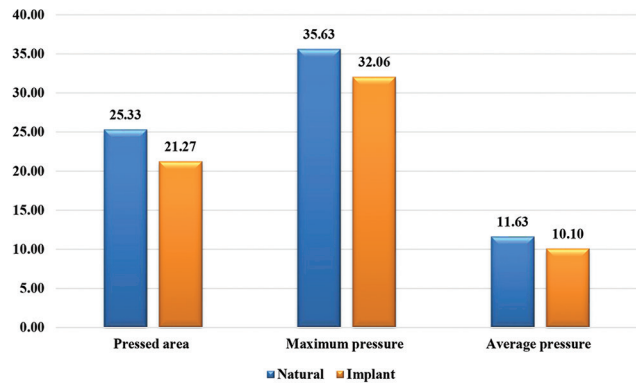
**Table 3: Descriptive Table: Group 1 – Implant prosthesis on the right side and contralateral side natural teeth**

Descriptive statistics					
Right side implant prosthesis	n	Mean	SD	Minimum	Maximum
Pressed area natural	15	30.27	11.83	17.00	54.00
Pressed area implant	15	26.27	9.79	14.00	46.00
Maximum pressure natural	15	34.35	3.44	28.00	40.30
Maximum pressure implant	15	31.61	3.78	25.00	38.00
Average pressure natural	15	11.73	1.39	9.80	14.50
Average pressure implant	15	10.15	1.72	7.00	12.50



**Table 4: Descriptive Table: Group 2 – Implant prosthesis on the left side and contralateral side natural teeth**

Descriptive statistics					
Left side implant prosthesis	n	Mean	SD	Minimum	Maximum
Pressed area natural	15	25.33	6.30	16.00	39.00
Pressed area implant	15	21.27	4.79	14.00	30.00
Maximum pressure natural	15	35.63	4.25	27.00	41.00
Maximum pressure implant	15	32.06	4.72	23.30	38.80
Average pressure natural	15	11.63	1.91	6.50	14.00
Average pressure implant	15	10.10	1.81	5.30	12.50

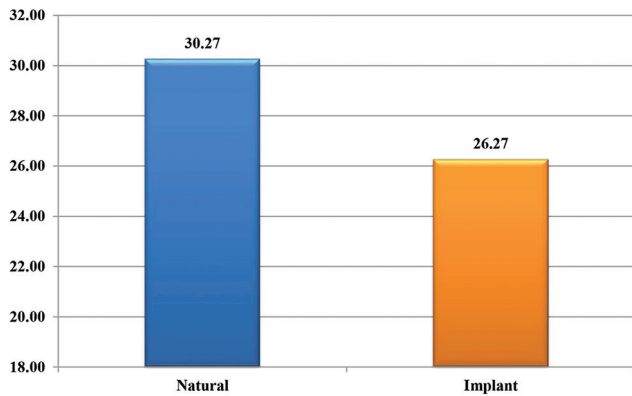


11.73 ± 1.39. Average mean bite pressure was found more in contralateral side natural teeth as compared to implant prosthesis and there was significant difference in average

**Table 5: Mandibular pressure record: Implant prosthesis on the right side and contralateral side natural teeth (pressed area)**

Particulars	Pressed area			P-value
	n	Mean	Std. deviation	
Natural	15	30.27	11.83	0.032*
Implant	15	26.27	9.79	

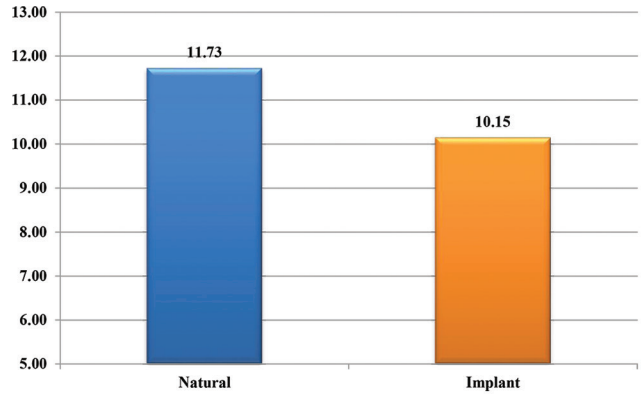
\*Statistically significant



**Table 7: Mandibular pressure record: Implant prosthesis on the right side and contralateral side natural teeth (average pressure)**

Particulars	Average pressure			P-value
	n	Mean	Std. deviation	
Natural	15	11.73	1.39	0.010*
Implant	15	10.15	1.72	

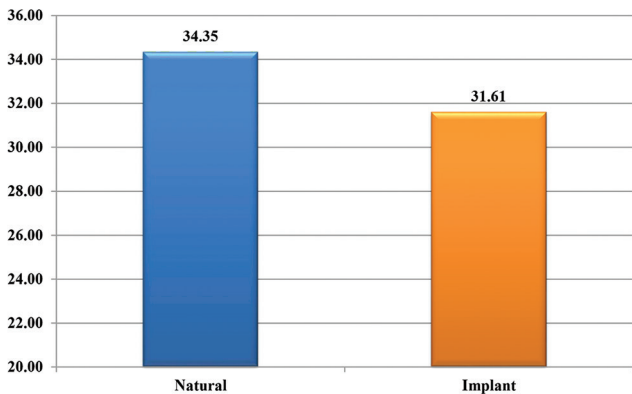
\*Statistically significant



**Table 6: Mandibular pressure record: Implant prosthesis on the right side and contralateral side natural teeth (maximum pressure)**

Particulars	Maximum pressure			P-value
	n	Mean	Std. deviation	
Natural	15	34.35	3.44	0.048*
Implant	15	31.61	3.78	

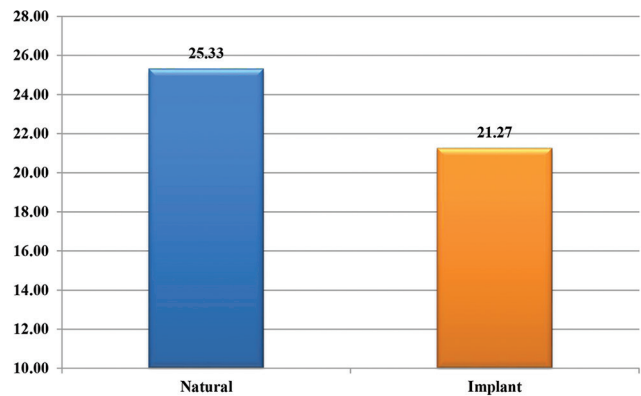
\*Statistically significant



**Table 8: Mandibular pressure record: Implant prosthesis on the left side and contralateral side natural teeth (pressed area)**

Particulars	Pressed area left			P-value
	n	Mean	Std. deviation	
Natural	15	25.33	6.30	0.045*
Implant	15	21.27	4.79	

\*Statistically significant



mean bite pressure between right side implant prosthesis and contralateral side natural teeth.

Amount of the pressed area at left side implant prosthesis was  $21.2 \pm 4.79$  and in contralateral side natural teeth was  $25.33 \pm 6.30$ . Mean amount of the pressed area was found more in contralateral side natural teeth as compared to

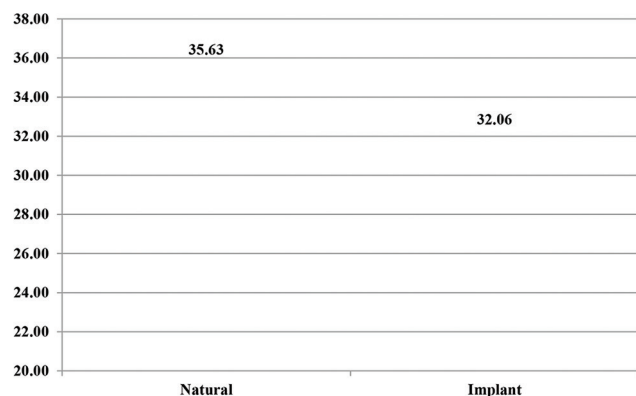
implant prosthesis and there was significant difference in mean amount of the pressed area in between left side implant prosthesis and contralateral side.

Maximum bite pressure at left side implant prosthesis was  $32.06 \pm 4.72$  and in contralateral side natural teeth  $35.63 \pm 4.25$ . Maximum bite pressure was found more in contralateral

**Table 9: Mandibular pressure record: Implant prosthesis on the left side and contralateral side natural teeth (maximum pressure)**

Particulars	Maximum pressure			P-value
	n	Mean	Std. deviation	
Natural	15	35.63	4.25	0.038*
Implant	15	32.06	4.72	

\*Statistically significant

**Table 10: Mandibular pressure record: Implant prosthesis on the right side and contralateral side natural teeth (average pressure)**

Particulars	Average pressure			P-value
	n	Mean	Std. deviation	
Natural	15	11.63	1.91	0.033*
Implant	15	10.10	1.81	

\*Statistically significant

side natural teeth as compared to implant prosthesis and there was significant difference in maximum bite pressure in between left side implant prosthesis and contralateral side natural teeth.

Average bite pressure at left side implant prosthesis was  $10.10 \pm 1.81$  and in contralateral side natural teeth was  $11.63 \pm 1.91$ . Average mean bite pressure was found more in contralateral side natural teeth as compared to implant prosthesis and there was significant difference in average mean bite pressure in between left side implant prosthesis and contralateral side natural teeth

## DISCUSSION

At present, there are two types of bite force measuring techniques available, that is, direct and indirect. Direct techniques include gnathodynamometer, lever spring, manometer spring and lever, micrometered devices, electronic transducers, strain gauges, digital occlusal force-meters, pressure-sensitive foils (PSFs), pressure transducers, digital

dynamometers, and dental pre-scale system (NUPAI bite scan system). They use of a suitable transducer placed between a pair of teeth. It is a convenient way to measure the bite force.

In the indirect method that includes electromyography, functional relationship between the bite force and physiological variables is evaluated as these variables are known to be functionally related to the bite force.<sup>[7]</sup> There are many factors that influence the magnitude of the biting force of an individual. These factors can be categorized into subject-related factors such as age, gender, body mass index, craniofacial morphology, temporomandibular disorders and pain, dental status, and psychological factors. Device-related factors include type of recording devices, amount of jaw separation as determined by thickness of device, type of measurement, device position, and patient position. The bite pressure also varied according to the occlusal schemes.

In the present study, bite force was measured using the NUPAI bite scan system. It consists of pressure-sensitive sheets. These sheets consist of pigment microcapsules placed one over the other, which burst according to the amount of pressure applied. The exposed PSFs are analyzed in the occlusal scanner. The scanner reads the area and color intensity of the red dots to assess occlusal contact area and pressure. It has following advantages as follows:

1. The thin material induces only a small change in the occlusal vertical dimension ( $98 \mu$  thickness) and makes it available to measure at a position near the intercuspal position
2. It is not necessary to prepare special measurement equipment
3. Many patients may be examined for a short time
4. Recording storage, even for an extended period, is simplified and
5. It is easy to explain the treatment to patients using dental images.<sup>[8]</sup>

The study also demonstrated that the maximum bite pressure values at the natural dentition side were significantly different from those of the implant prosthesis side using NUPAI bite scan. In the present study, a within-subject study design was applied and the other side of the jaw of the same patients was used as control. Pressure values were lesser on implant prosthesis side. The detected difference between implant treated and the natural dentition sides could have been influenced by the chewing side preference as implant side was edentulous for longer time.<sup>[9,10]</sup> Furthermore, the potential of jaw flexure as well as variations in muscle tonicity during unilaterally closing down on hard objects might potentially affect the recorded bite force value. The present study demonstrated that the maximum bite pressure values at the natural dentition sides were significantly different from those at the implant

prosthesis. The accuracy and precision of bite pressure measurements might be influenced by the mechanical features of the used bite pressure measuring system.

In this study for Group-1: Implant prosthesis on the right side and natural teeth on contralateral side pressed area  $P = 0.032$ , which is significant ( $P < 0.05$ ).  $P$ -value for maximum bite pressure is 0.048, which is significant ( $P < 0.05$ ).  $P$ -value for average bite pressure is 0.010, which is significant ( $P < 0.05$ ). For Group-2: Implant prosthesis on the left side and natural teeth present on contralateral side pressed area  $P = 0.045$ , which is significant ( $P < 0.05$ ).  $P$ -value for maximum bite pressure is 0.038, which is significant ( $P < 0.05$ ).  $P$ -value for average bite pressure is 0.033, which is significant ( $P < 0.05$ ).

## CONCLUSION

In the present cross-sectional study, NUPAI bite scan system has been used to compare the maximum biting pressure within the same patient on the mandible where one side has natural dentition and the contralateral side had been restored with an implant prosthesis. Within the limitations of this study, the following conclusions are drawn relative to the bite pressure on mandibular implant prosthesis on the 1<sup>st</sup> molar region and natural mandibular 1<sup>st</sup> molar tooth on contralateral arch.

- There is significant difference between pressed area on implant prosthesis and on natural tooth. For Group-1:  $P < 0.05$  was considered and for Group-2:  $P < 0.05$  was considered
- There is significant difference between maximum bite pressure on implant prosthesis and on natural tooth. For Group-1:  $P < 0.05$  was considered and for Group-2:  $P < 0.05$  was considered
- There is significant difference between average bite pressure on implant prosthesis and on natural tooth. For Group-1:  $P < 0.05$  was considered and for Group-2:  $P < 0.05$  was considered.

Maximum bite pressure values can be used to compare and evaluate health of implant and peri-implant tissues. Implant prosthesis should be prevented from being overload with heavy masticatory forces. Poor occlusal

system selection can lead to biological and mechanical complications. Heavy masticatory forces can lead to implant failure, early crestal bone loss, screw loosening, uncemented restorations, component failure, porcelain fracture, prosthesis fracture, and peri-implant disease. For prevention of such consequences, NUPAI bite scan system is very helpful and has following advantages:

- The thin material induces only a small change in the occlusal vertical dimension (98  $\mu$  thickness)
- Makes it available to measure at a position near the intercuspal position
- It is not necessary to prepare special measurement equipment
- Many patients may be examined for a short time
- Recording storage, even for an extended period, is simplified and
- It is easy to explain the treatment to patients using dental images.

Thus, it can be concluded that maximum bite pressure records using NUPAI bite scan system can be very helpful in maintaining health of implant and peri-implant tissues.

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