ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 2, April - 2023, Page No. : 304 – 323

A comparative study to evaluate the reverse torque values of two different implant abutments with 2mm and 4mm gingival collar height at a torque value of 30 NCM on cyclic loading - An in vitro study.

[1]Dr. Santosh Dixit, Head of Department, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[2]Dr. Pooja Radke, Postgraduate Student, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[2]Dr. Varun Deshpande, Reader, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[3]Dr. Vikram Rathod, Reader, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[3]Dr. Priyanka Jeve, Postgraduate Student, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[4]Dr. Ravikiran Asbe, Senior Lecturer, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

[4]Dr. Priti Mehta, Senior Lecturer, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

Corresponding Author: Dr. Pooja Radke, Postgraduate Student, Department of Prosthodontics, Crown & Bridge, Pandit Deendayal Upadhyay Dental College & Hospital, Solapur, Maharashtra.

Citation of this Article: Dr. Santosh Dixit, Dr. Pooja Radke, Dr. Varun Deshpande, Dr. Vikram Rathod, Dr. Priyanka Jeve, Dr. Ravikiran Asbe, Dr. Priti Mehta, “A comparative study to evaluate the reverse torque values of two different implant abutments with 2mm and 4mm gingival collar height at a torque value of 30 NCM on cyclic loading - An in vitro study”, IJDSIR- April - 2023, Volume – 6, Issue - 2, P. No. 304 – 323.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

The purpose of this in vitro study was to evaluate the effect of different angulation and collar lengths of the implant abutment screw loosening by measuring removal torque values before and after dynamic cyclic loading.

Method: Total no of 4 implant fixtures having diameter of 4.5 mm and 4 implant abutments with two straight and two angulated were used in this study (fig.2,3). The gingival collar height used was 2mm and 4mm for straight and angulated abutment respectively. They were divided into four groups – GP 1- Straight abutment with

2mm gingival height, GP 2- Straight abutment with 4mm gingival height, GP 3- Angulated abutment with 2mm gingival height, GP 4- Angulated abutment with 4mm gingival height. Total no of 60 abutment screws were used, 15 in each group. A rectangular stainless-steel model with a hole as per the diameter of implants at the centre of the model were fabricated for this study. Each implant and abutment assembly were positioned vertically in the centre of the stainless-steel model. Initial analysis was made by abutment screw tightened with 30 Ncm torque twice with 10- min interval using torque gauge. Rtv before and after cyclic loading of the abutment screws were measured in new ton centimetre using torque gauge.one hundred thousand cycles of eccentric dynamic cyclic loading, at 130 N at a rate of 1 Hz, were applied 5mm away from the central axis of the implant fixture. After dynamic cyclic loading, reverse torque value of abutment screw was measured. Above mentioned procedure was repeated for all groups and statistically analyzed.

Result: Group 1 having gingival collar height 2 mm shows less reverse torque values than group 2 having gingival collar height 4mm. Group 3 Angulated abutments having gingival collar height 2 mm shows less reverse torque value than group 4 having gingival collar height 4 mm. Screw loosening increases with increasing abutment angulation and collar height after 100,000 cycles of dynamic cyclic loading.

conclusion: Within the limitation of this study, result suggested that screw loosening increases with increasing abutment angulation and coller lengths after dynamic cyclic loading.

Keywords: Implant, screw loosening, reverse torque, abutment angulation, abutment collar height, cyclic loading

Introduction

Oral implantology has undergone a well-deserved rebirth or rediscovery and implants considered the treatment of choice in an increasing number of carefully selected cases.

After Osseo integration is achieved, long-term clinical follow-ups reported bio logical or mechanical complications.[1] Survival rate of implant-supported single crowns concluded that the cumulative incidence of abutment screw or abutment loosening was 7.3% in both external and internal connections from the 26 clinical studies included.[2] Screw loosening may cause implant or screw fracture, inadequate occlusal force distribution, and possible osseointegration failure. In addition, screw loosening would also lead to micro motion at the implant-abutment interface while chewing.[3] Failures are due to many factors related to screw design and fabrication may affect abutment or prosthetic screw loosening in a metal-to-metal screw system; these primarily are related to preload. Preload can be influenced by com ponent and screw materials[8,9], torque delivery systems[10], Manu facturer's quality control[11], screw joint design, surface roughness, and fatigue testing.[12] It was reported that the main factor in screw loosening was an in appropriate tightening torque. If the tightening torque was not consistent, the following preload showed a difference and could affect the removal torque.[12] In addition, factors that affect abutment screws loosening include hex height (or depth), diameter of the screw, plat form diameter, surface condition, vibrating micro movement, excessive bending, micro leak age, abutment connection, abutment diameter, surface coating, cement wash out, collar length, abutment angulation, lateral cyclic loading, inadequate tightening torque, retorque, reverse torque, and settling effect.[13] One of the variables that influence the joint stability is how the contacting parts change when the screw is tightened. After being tightened together by the screw, the micro-roughness of all the metal contacting surfaces slightly flattens, and the microscopic distance between contacting surfaces de creases.[15] As a result of this process called "settling," the screw loses part of its preload. For this reason, de torque values immediately after tightening are always lower than the initial tightening torque.[16]When evaluating the screw loosening of new abutment screws and after successive tightening, it was found that the percentage of the initial torque loss is lower when screws that already suffered the application of an initial torque were used, remaining stable after application of successive torques that is why retightening theold screw is a current option.

It was strongly recommended that retightening of implant abutment screw is important to decrease the possible screw loosening. Pardal-Peláez et al.[18] have stated that the most effective strategy is to retighten the screws 10 min after the first tightening, after the 1st year of function and then periodically to compensate the settling effect.

Bulaqi et al.[19] have recommended that retight ening reduced the settling effect and had an insignificant effect on the preload. At high coefficients of friction, the retightening effect was intensified. Farina et al.[20] concluded that the retorque application significantly increases the loosening torque when titanium and gold screws are used. If the abutment screw is exposed to excessive wear and still in place, screw replacement is a good option. Hum[21] has introduced a special technique to accurately locate the loose abutment screw and replace it with a new one. Screw replacement may be of damaging effect especially for cement-retained metal-ceramic restorations with ceramic occlusal surfaces. Schwedhelm et al.[22] introduced a technique for locating implant abutment screws of such restorations that may facilitate the clinician's ability to locate the abutment-screw access in the event of abutment-screw loosening, thus reducing the need for refabricating the restoration.

When the implant set is submitted to functional loads, occlusal forces to the connection are con cent rated at the abutment screw; consequently, the optimum preload is critical for joint stability and to avoid screw loosening.[6] Several factors related to screw design and fabrication can affect the risk of abutment or prosthetic screw loosening in a metal-to-metal screw system; these primarily are related to preload which by itself is affected by multiple factors: torque magnitude, screw head design, thread design, and number and composition of metal. There are some factors that can affect initial torque loss, including tightening torque value, implant system, abutment screw material, errors in casting of metallic alloys, repeated tightening/loosening cycles of the screw, and improper insertion torque. These factors can reduce the frictional fit between the screws and internal threads of the implant, which may lead to screw loosening.[8,9]

Also screw loosening may be caused by inadequate tightening torque, settling of implant components, in ap propriate implant position, inadequate occlusal scheme or crown anatomy, poorly fitting frameworks, improper screw design/material, increased abutment angulations, increased collar length, and heavy occlusal forces.

Ideally, dental implants should be aligned vertically with the axial forces. When the long axis of the implant fixture and the long axis of the planned prosthetic tooth are not aligned, due to improper jaw relationship or compromised osseous anatomy, angled abutment is often the abutment of choice for prosthodontic restorations it helps to avoid vital anatomical structures. Angled abutments are used in all-on-four and all-on-six approaches in completely edentulous patients. They can be used for esthetics reasons. Angled abutments reduce treatment time, fees, and the need to perform guided bone regeneration procedure.[11]

Kallus et al.[9] demonstrated prototype angled abutments of the Brånemark**.** Nowadays, angled abutments vary from 15 to 45° angulation. Researches showed that angled abutment developed transverse force under loads in the direction of angled abutment resulting in off-axis forces. When functional or parafunctional load is applied to angled abutment, it generates micromovement which might playa role in screw loosening.

Collar length is the distance between the implant plat form and the gingival margin. Sometimes, significant vertical space that has not been corrected with vertical ridge augmentation may necessitate selection of longer abutments, which would lead to an increased vertical cantilever. Furthermore, selection of the length of abutment collar would be affected if different distances between the implant platform and the gingival margin exist. Despite consistent occluso-gingivial dimension, the thickness of soft tissue around the abutment affects abutment collar length selection of the suitable abutment collar length from a prosthetic/Esthetic point of view is influenced by the length of the implant collar used. Abutment collar length is determined based on the height of the emergence profile and prosthetic restoration type (cemented, screw-retained,or overdenture).[12]

The application of dynamic cyclic loading is used to simulate masticatory function mimic oral cavity that might lead to a failure of implant–abutment connection. Also, it is a reliable method to test the effect of mechanical fatigue on the implant–abutment stability.[10]

There are limited data in the literature regarding the investigation of reverse torque values of variations in abutment angulations and collar height before and after dynamic cyclic loading. This in vitro study aims to evaluate the effect on reverse torque values with different abutment angulation and gingival collar height on dynamic cyclic loading.

Material and Methods

Instruments, equipment's and material used in this study are1. Dental Implants (Osstem Co., Seoul, Korea) 2. Standard abutment with gingival collar height 2mm and 4mm (Osstem Co., Seoul, Korea) 3. Angulated abutment with gingival collar height 2mmand 4mm (Osstem Co., Seoul, Korea) 4. Stainless steel model 5. Dental surveyor (Dental farm. Torino. Italy) 6. Torque gauge (Osstem Co., Seoul, Korea) 7. Hex driver (Osstem Co., Seoul, Korea) 8. Metal mounting jig 9. Resin cement RelyXTM U200 (3M ESPE) 10. Universal testing machine

Total no of 4 implant fixtures having diameter of 4.5 mm and 4 implant abutments

with two straight and two angulated were used in this study (fig.2,3). The gingival

collar height used was 2mm and 4mm for straight and angulated abutment.

respectively. They were divided into four groups as below –

- Group 1- Straight abutment with 2mm gingival height
- Group 2- Straight abutment with 4mm gingival height
- Group 3- Angulated abutment with 2mm gingival height
- Group 4- Angulated abutment with 4mm gingival height

Total no of 60 abutment screws were used, 15 in each group (fig9).

A rectangular stainless-steel model with a hole as per the diameter of implants at the centre of the model were fabricated for this study. Implant were then embedded vertically perpendicular to the base of the model. Straight abutment and angulated abutments (17 degree) were screwed to the implant respectively (fig.4,5). A customized rigid metal mounting jig was fabricated to be fixed on to implant abutment assembly with resin cement (fig. 6,7).

Abutment screws were hand tightened using hex driver, then predetermined torque value of 30 NCM was applied on abutment screw. The placement torque was measured by the torque gauge. All screws were retightened to the same tightening torque (30Ncm) after 10 min of first torque application. Initial removal torque values before cyclic loading were measured and recorded.

The entire assembly of implant abutment and customized rigid metal mounting jig was mounted on universal testing machine for 100000 cycles of eccentric dynamic cyclic loading (fig.10). Dynamic cyclic loading was performed under a load of130 N with contact time between the rod and the metal tube 0.2 s at a rate of 1 Hz which simulates the tooth contact duration of each masticatory cycle. The load was then applied on the jig perpendicular to the metal tube and 5 mm away from the Center axis of implant.

After dynamic cyclic loading, reverse torque value of abutment screw was measured. Above mentioned procedure was repeated for all groups and statistically analyzed.

Result and discussion

In this study, the results and data analyzed has been presented in the form of tables.

1. Descriptive study details

This study comprised of total 60(n) samples under four groups of two different implant abutments with 2mm and 4mm gingival collar height subjected to torque of 30 (N-cm) with 15 (n) samples each as shown in figure 1 and 2.

A) Osstem Straight implant abutment

A total of 30 samples were included under osstem straight implant abutment. They

were categorized with 2 mm and 4 mm gingival collar height subjected to a torque.

of 30 N-cm with a sample of 15(n).as shown in figure 2.

B) Osstem Angular implant abutment

A total of 30 samples were included under osstem angular implant abutment. They were categorised as 2mm, and 4 mm of gingival collar height subjected to a torque of 30 N-cm with a sample of 15(n).as shown in figure 3.

Test for Data Normality

For testing, whether the data is normally distributed or not, we used both kolmogorov - smirnov test and shapiro - wilk test for checking the normal distribution of data with the p value or the alpha value 0.05 as the standard as shown in table 1. It was seen that the value of both kolmo gorov smirnov test and shapiro the distribution of the data was also observed for all the given para meters through histograms and normal Q-Q plot. For all the parameters, it was seen that the mid points of his to grams as shown in graph 1, for all parameters when joined, forms a linear line of normal distribution with no presence of kurtosis and skewness or no deviation of data to the extremes were evident.

The mean value of the parameters was not shown deviation towards the extreme while the standard deviation values were less, as depicted in Q-Q plot as shown in graph 2 below, with the data from samples following the line of distribution towards the mean or the expected value did not deviate more from the approximate or the original value.

The error bar as shown in graph 3 below for all parameters, did not show more variance towards the extreme as the median value do not show more deviation towards the upper (25th percentile) and lower value (75th percentile)

The results of the study are as follows

Table 1: Comparison between osstem straight and osstem angular at initial torque as shown in table, the t test was used to carry out the difference in the values between the two samples. The values were compared individually with each other by keeping p value <0.05 as statistically significant. Group statistics was carried out between torque value at 30 N-cm. By comparing the means between the values, no significant difference was observed (p >0.05).

Table 2: Comparison between straight and osstem angular at initial removal torque

As shown in table, the t test was used to carry out the difference in the values between the two samples. The values were compared individually with each other by keeping p value <0.05 as statistically significant. Group statistics was carried out between torque values at 30 N-cm. By comparing the means between the

values, no significant difference was observed (p >0.05).

Table 3: Comparison between osstem straight and osstem angular After 100000cycles removal torque

As shown in table, the t test was used to carry out the difference in the values.

between the two samples. The values were compared individually with each other.

by keeping p value <0.05 as statistically significant. Group statistics was carried.

out between torque value of 30 N-cm. By comparing the means between the values,

no significant difference was observed (p >0.05).

Table 4: Comparison between osstem straight 2 mm and osstem straight 4 mm at initial removal torque

As shown in table, the t test was used to carry out the difference in the values.

between the two samples. The values were compared individually with each other by keeping p value <0.05 as statistically significant. Group statistics was carried.

out between torque values of 30 N-cm. By comparing the means between the

values, no significant difference was observed (p >0.05).

Table 5: Comparison between osstem straight 2 mm with osstem straight 4 mm After 100000 cycles removal torque

As shown in table, the t test was used to carry out the difference in the values.

between the two samples. The values were compared individually with each other.

by keeping p value <0.05 as statistically significant. Group statistics was carried.

out between torque values of 30 N-cm. By comparing the means between the

values, no significant difference was observed (p >0.05).

Table 6: Comparison between Angular 2 mm with angular 4 mm at initial removal torque

As shown in table, the t test was used to carry out the difference in the values.

between the two samples. The values were compared individually with each other.

by keeping p value <0.05 as statistically significant. Group statistics was carried.

out at torque value of 30 N-cm. By comparing the means between the values, no

significant difference was observed (p >0.05).

Table 7: Comparison between Angular 2 mm with angular 4 mm After 100000cycles removal torque

As shown in above table, the t test was used to carry out the difference in the values between the two samples. The values were compared individually with each other by keeping p value <0.05 as statistically significant. Group statistics was carried out at a torque values of 30 N-cm. By comparing the means between the values, no significant difference was observed (p >0.05).

Figure 1: Osstem Implants

Figure 2: Straight abutment with gh 2mm and 4mm

Figure 3: Angulated abutment with gh 2mm and 4mm

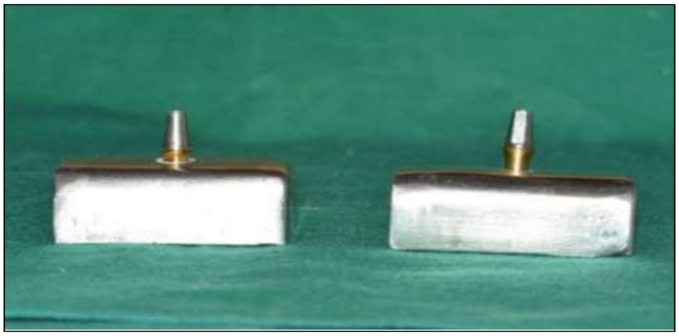


Figure 4: Straight abutment fixed to implant.

Figure 5: Angulated abutment fixed to implant.

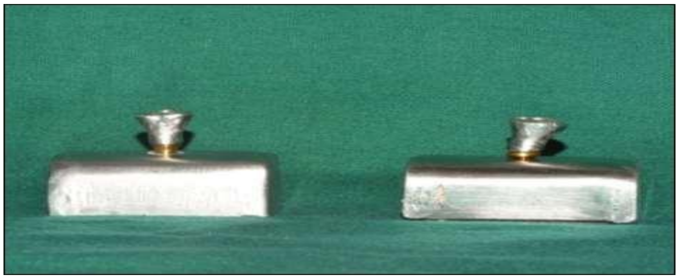


Figure 6: Implant abutment (2 mm gh) with metal mounting jig

Figure 7: Implant abutment (4 mm gh) with metal mounting jig.

Figure 8: Metal model with surveyor

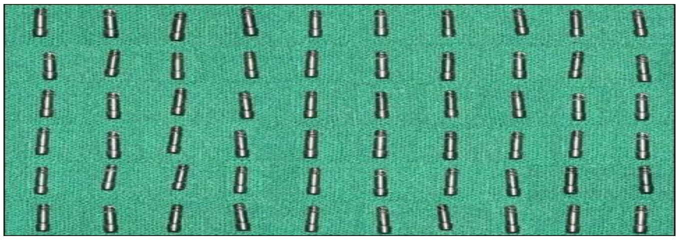


Figure 9: Implant abutment screws

Figure 10: Application of cyclic loading with universal testing machine

Figure 11: Material and equipment

Tables

Table 1: Nature of data distribution

	Kolmogorov-smirnov test			Shapiro-wilk test		
	statistics	Df	Sig.	statistics	Df	Sig.
osstem straight 2mm	.09	15	.002	.898	15	.05
osstem straight 4mm	.21	15	.120	.888	15	.05
osstem angular 2mm	.10	15	.175	.951	15	.059
osstem angular 4mm	.10	15	.175	.940	15	.059

Table 2: Comparison between osstem straight and osstem angular at initial torque-

	Sample	N	Mean	Std. Deviation	Std. Error Mean
	Osstem straight	30	23.50	.707	.50
Value					
	Osstem angular	30	24.00	1.41	1.00

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed value	.	.	-.447	2	.698	-.50	1.11	-5.31	4.31
Equal variances not assumed			-.447	1.471	.712	-.50	1.11	-7.41	6.41

Table 3: Comparison between osstem straight and osstem angular at initial removal torque

Group Statistics

	Sample	N	Mean	Std. Deviation	Std. Error Mean
Value	osstemstraight	30	18.50	.70	.50
	Osstem angular	30	20.50	.70	.50

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed value	.	.	-2.82	2	.106	-2.00	.70	-5.04	1.04
Equal variances not assumed			-2.82	2.0	.106	-2.00	.70	-5.04	1.04

Table 4: Comparison between osstem straight and osstem angular After 100000 Cycles removal torque

Group Statistics

	Sample	N	Mean	Std. Deviation	Std. Error Mean
Value	osstemstraight	30	21.50	3.53	2.50
	Osstem angular	30	23.00	2.82	2.00

	Levene's Test forEquality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed. value	.	.	-.469	2	.686	-1.50	3.20	-15.27	12.27
Equal variances not assumed			-.469	1.90	.687	-1.50	3.20	-15.93	12.93

Table 5: Comparison between osstem straight 2 mm and osstem straight 4 mm at Initial removal torque

Group Statistics

	Sample	N	Mean	Std. Deviation	Std. Error Mean
Value	osstem straightwith 2 mm	15	21.00	4.24	3.00
	osstem straightwith 4 mm	15	22.00	4.24	3.00

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed			-.236	2	.836	-1.00	4.24	-19.25	17.25
value	.	.							
Equal variancesnot assumed			-.236	2.00	.836	-1.00	4.24	-19.25	17.25

Table 6: Comparison between osstem straight 2 mm with osstem straight 4 mm After100000 cycles removal torque.

Group Statistics

	Sample		N	Mean	Std. Deviation	Std. Error Mean
	osstemstraight with mm	2	15	21.00	4.24	3.00
Value	osstem					
	straightwith mm	4	15	22.00	4.24	3.00

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed			-.236	2	.836	-1.00	4.24	-19.25	17.25
value	.	.							
Equal variancesnot assumed			-.236	2.000	.836	-1.00	4.24	-19.25	17.25

Table 7: Comparison between Angular 2 mm with angular 4 mm at initial removal torque

Group Statistics

	Sample	N	Mean	Std. Deviation	Std. Error Mean
Angular with 2 mm		15	26.00	4.24	3.00
Value					
Angular with 4 mm		15	22.00	1.41	1.00

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	5% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.	.	1.26	2	.333	4.00	3.16	-9.60	17.60
value									
Equal variances not assumed			1.26	1.22	.396	4.00	3.16	-22.54	30.54

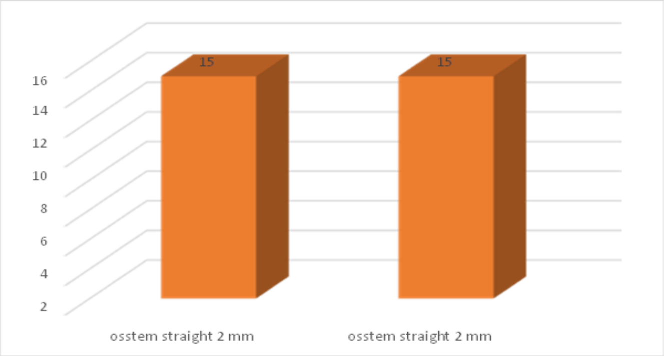
Table 8: Comparison between Angular 2 mm with angular 4 mm After 100000 Cycles removal torque

Group Statistics

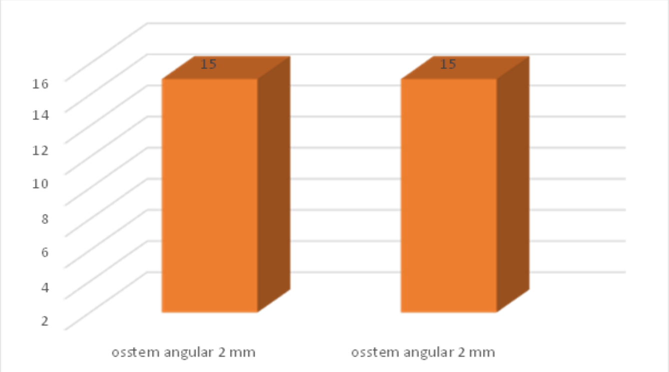
	Sample	N	Mean	Std. Deviation	Std. Error Mean
Value	Angular straight with 2 mm	15	26.00	4.24	3.00
	Angular straight with 4 mm	15	22.00	1.41	1.00

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.	.	1.26	2	.333	4.00	3.16	-9.60	17.60
value									
Equal variances not assumed			1.26	1.220	.396	4.00	3.16	-22.54	30.54

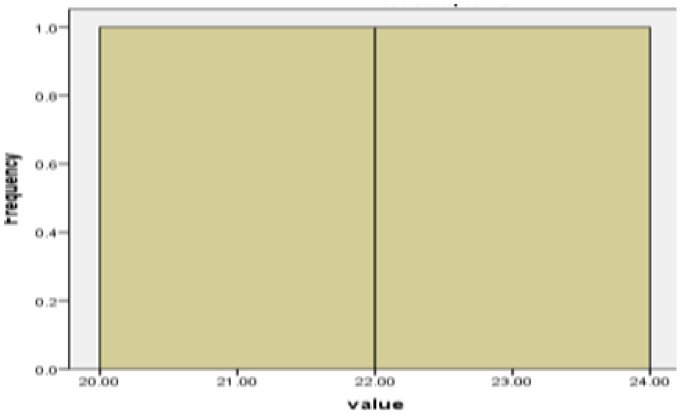
Graph 1: Sample distribution of osstem straight implant abutments



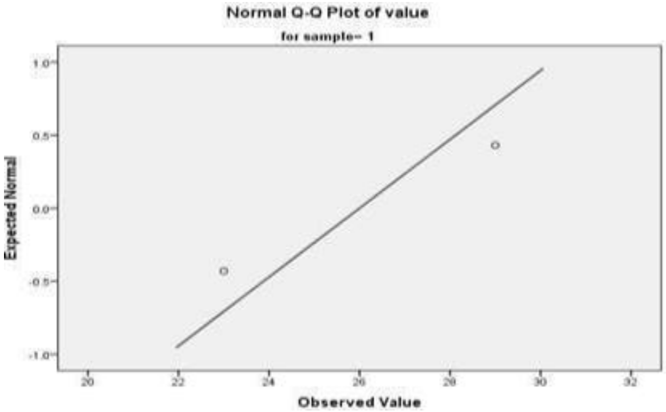
Graph 2: Sample distribution of osstem angular implant abutments.



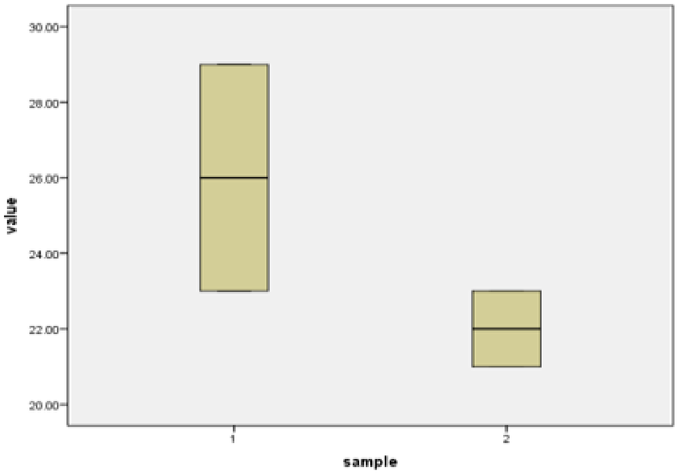
Graph 3: Data normality through histogram



Graph 4: Data normality Q-Q histogram



Graph 5: Data normality through error bardiagram.



Annexures

Table 1: Readings for Osstem straight 2mm

Initial Torque	Initial Removal Torque	After 100000 cycles Removal torque
30	23	20
30	18	15
30	12	9
30	31	25
30	22	18
30	16	13
30	17	14
30	18	15
30	11	8
30	18	12
30	21	18
30	23	20
30	27	24
30	24	21
30	18	8

Table 2: Readings for Osstem straight 4mm

Initial Torque	Initial Removal Torque	After 100000 cycles Removal torque
30	21	19
30	30	13
30	22	7
30	16	25
30	15	17
30	17	11
30	9	12
30	16	13
30	12	6
30	19	10
30	22	16
30	23	17
30	26	21
30	22	19
30	17	6

Table 3: Readings for Osstem angular 2mm

Initial Torque	Initial Removal Torque	After 100000cycles Removal torque
30	20	16

30	19	15
30	13	8
30	29	24
30	23	19
30	17	12
30	18	14
30	19	15
30	12	7
30	19	14
30	20	14
30	24	19
30	26	22
30	25	19
30	12	7

Table 4: Readings for Osstem angular 4mm

Initial Torque	Initial Removal Torque	After 100000cycles Removal torque
30	24	16
30	18	11
30	12	6
30	30	22
30	22	14
30	16	10
30	17	11
30	18	12
30	11	5
30	18	12
30	21	13
30	23	17
30	27	22
30	24	20
30	11	12

Discussion

Oral implantology has undergone a well-deserved rebirth and rediscovery and dental implants are considered as the treatment of choice.[2] Long-term clinical follow-ups reported that the survival rate of single tooth implants over 6 years period is 97%.[1] However there are a few factors contributing to the implant survivaland failure.

The various mechanical factors causing failure are abutment screw loosening, abutment screw fracture, prosthetic screw loosening/ fracture, implant fracture due to improper occlusal forces distribution.[2] Studies that evaluated the reverse torque values reported that screw loosening is one of the major complications of dental implant therapy.[3] In addition it would also lead to micromotion at the implant – abutment when in function.[2]

Collar height is the distance between the implant platform and the gingival margin. Sometimes significant vertical space that has not been corrected with vertical ridge augmentation would lead to an increased vertical cantilever. Abutment selection according to collar height index is critical mechanical factor; selection of improper abutments leads to an increased vertical cantilever which acts as a forcemagnifier.[4] Periimplantitis is known to be one of the most important factor associated with late failure with relation to improper abutment collar height.[5] There is limited data in the literature regarding the investigation of reverse torque values of variations in abutment angulations and collar height before and after dynamic cyclic loading. This in vitro study aims to evaluate the effect on reverse torque values with different abutment angulation and gingival collar height on dynamic cyclic loading.[6]

For many years now, the loss of natural teeth has created a need for tooth replacement for both aesthetic and functional reasons.[7] In 1978, Brånemark and Albrektsson presented, at Harvard University, the results of their fifteen-year-long investigation concerning the integration of titanium in bones, at which time they coined the terms ‘osseointegration’ and ‘the implant-pros thetic complex'. The latter refers to an Osseo-integrated implant whose connection can either be internal or external.[8] The implant comprises a prosthetic abutment, over which the crown is placed, and a screw that joins the abutment to the implant. Initially, Osseo- integrated implants presented a high success rate (being 84% in the maxilla and 93% in the mandible during a 5-12 years observation period; however, soon after, relatively high levels of loosening of the abutment screw were observed (12.7% at 5 years).[9] This loosening is one of the main problems associated with pros thetic implants. Moreover, it has been shown that 43% of abutment screws become loose during the first year of placement, and that the cause of this loosening can be due to either the incorrect biomechanical design of the interface or occlusal overload.[10] Also, if the loosening process continues over a long period of time it could lead to screw fracture (0.35% at 5 years).[11] The first dental im plants were comprised of an external connection system (0.7 mm- high hexagon), with internal connection im plants appearing later.[12] In the external connection, the hexagonal anti-rotational component is the most frequently used; however, the rate of loosening with this type of connection has been shown in the literature to be between 6 and 48%.[13] In the case of the internal connection, internal hexagon or octagon are used and allow for a more exact union between the implant and the abutment, which in turn reduces the movement of the inter face and in principle decreases screw loosening.[14] An other option for an internal connection is the morse taper that introduces an internal cone of 8° or 11°. It has been proposed that the morse taper joint could protect against screw loosening.[15]

Abutment screw stability can be affected by preload, the effect of settling, and screw geometry. Preload is the force, measured in volts and later transferred to newton, that is generated when a screw is tightened within a given torque.[16] Only 10% of the initial torque is transformed into preload, where the remaining 90% is used to overcome the friction between the surface irregular rities.[17]

Another important phenomenon experienced by the screw joint is the settling effect. This occurs because neither the interior torque nor the screw is perfectly fabricated without irregularity, and therefore these rough areas are smoothed out causing a loss of 2-10% of the initial preload.[13] It is known that the preload should not be too high and should be lower than 75-80% of the elastic limit of the material.[15] If the forces applied onto the system are greater than the preload, screw loosening takes place.[15]

From a clinical point of view, it is thought that screw loosening is greater in an external connection than in an internal connection, where the incidence of loose screws is 38% in systems with an external hexagon. However, there are no qualitative data comparing loosening between external and internal connections Torque loosening causes micro movements in the interface to appear that generate both mechanical problems (increased loosening and failure of the screw, abutment and implant body) and biological problems. In the case of bio logical problems, micro-spaces that form within the interface permit the colonization of bacteria that can cause mucositis, peri-implantitis and finally implant loss, especially when the implant-prosthesis are subjected to cyclic loads.[18]

The clinician should be aware, when selecting the type of implant and torque to be applied, that the abutment screw can be influenced in terms of the biomechanical yield of the implant-prosthesis.[19]

Many implant systems with screw-retained abutments have been in use for several decades with well-documented clinical success. These systems consist of an implant and an abutment joined together with a titanium abutment screw. The long- term predictability of Osseo-integrated oral implants has been well documented, and implant failures are fortunately rare.[20] It is important to try to understand the etiopathogenesis of these failures in order to minimize them. Moreover, from this knowledge we can hope to improve the quality of the materials and the surgical and prosthetic techniques.[21] Implant failures may be categorized as bio logical, mechanical, iatrogenic, and functional. They most likely originate either from implant overloading or from bacterial infection of the peri-implant tissues.[22]

The most common failure associated with dental implant is screw loosening and fracture of implant.[23] One of the major causes for screw loosening is the "loss of preload." Preload is the axial force in the neck of the screw, which is between the first mating thread and head of the abutment screw.[24] The tensile force clamps the abutment to the implant.[25] The relationship between applied torque and preload depends on several factors including screw geometry, material properties, surface texture, degree of lubrication, rate of tightening, and integrity of joint. This study aim at determining the factors which causes loss of preload in dental implants.[26]

One of the most common mechanical problems in implant prostheses is the joint loosening and fracture that occur in the screw joint portion between the implant fixture and the abutment.[27] Joint loosening, along with the mechanical failure of the implant prosthesis, may cause bio logical complications such as tissue in flammation around the implants, gingival growth, and fistula formation. In particular, joint loosening in an implant treatment restored with the concept of immediate loading may cause harmful stress to the alveolar bone prior to the osseointegration, leading to the failure of the osseointegration.[28]

The fixture-abutment connection type for the implant system, which is widely used in clinical practice at present, is mainly classified into the external butt joint and the internal cone.[29]

Screw loosening is caused by an inappropriate tightening torque, the surfaces inking phenomenon, screw deformation and preload loss due to overload, and vibration due to the functional load.[30] The preload, which is a com pressed force that occurs between the abutment and the fixture due to the tightening torque, increases as the tightening torque increases and the friction coefficient of the screw decreases.[31] If the tightening torque is applied to the abutment screw, or if the external load is applied to the implant superstructure, the surface roughness wear is smoothened due to the compressed force. This settling effect reduces the preload, which leads to screw loose ning.[32] To compensate for the preload loss caused by sur face sinking in actual clinical practice, the tightening torque must be applied again 10 minutes after a new screw is fastened, and the tightening torque must be regularly and repeatedly applied after the functioning of the implant prosthesis[33]. In this study, based on previous reports, the tightening torque was repeatedly applied 10 minutes after the screw was fastened, and after 10,0000 cycles of repeated loads to compensate for the surface sinking caused by the functional load.[34]

For the external butt joint connection type, the stress caused by all the external loads, except for the tightening torque and the load of the implant major axis, is applied to the screw.[35] The external hexagon of the external butt joint was developed to provide the abutment direction upon the fixture installation and the superstructure Manu facturing, and it was difficult to achieve resistance against the lateral force.[36] In addition, the fulcrum length for the lateral force was longer compared to the internal cone connection type, and most external hexagons have a gap in the hexagon between the abutment and the fixture, and mainly depend on the friction caused by the preload for the torsion stress.[37] Therefore, it is very important to apply the appropriate preload to stabilize the connection parts in the external butt joint. On the other hand, in the internal-cone-connection type implant system, the tightening torque is driven by not only the screw height but also the wedge effect due to the conical abutment sinking, and the load is mainly supported by the internal slope of the fixture.[38] Therefore, the stress that occurs in the abutment screws has been known to be relatively smaller than that in the external butt joint.[39] In the internal cone implant system, however, the tensile force of the abutment screw, that is, the preload, was reported to have been slightly reduced due to the slight sinking of the abutment caused by the vertical com ponent of the load. In the external butt joint implant system, the preload loss was reported to have been relatively smaller due to the vertical support of the upper fixture.[40]

The preload, which is a contributing factor to the stability of the screw connection parts, is affected by various factors associated with the elongation of the abutment screw.[41] The measurement of the removal torque of the abutment screw is one of the methods for indirect comparison of preloads.[42] By measuring the initial removal torque, the reductions in the degree of the preload caused by the tightening torque can be compared. The factors that affect the initial removal torque include friction, surface sinking, and abutment sinking. By measuring the removal torque and calculating the loss rate after the repeated loads that are clinically more important, the reduced preloads due to the external load, that is, the joint stability against the functional load, can be indirectly compared.[43] The joint stability against the functional load is affected by the surface sinking of the implant system, the joint micro-movement, the abutment screw deformation, and the abutment sinking.[44]

Theoretically, if the implant system diameter increases, the preload loss caused by the bending load during the functional movement relatively decreases due to the increased area between the abutment and the fixture.[45] It was reported that the joint opening due to the fulcrum load was lower in the wide-diameter implant system than in the regular-diameter implant system in a repeated load experiment in which a strain gauge was used.[46] When the fulcrum load at the upper fixture was applied to a 10 mm-tall metal tube, the external force that was applied to the abutment screw was calculated in the moment form using the following formula.[34]

$Fs = [(Fh \times 10) - (Fv \times Lv)] / (0.5 \times d)$ wherein Fs is the external force applied to the abutment screw, Fh is the horizontal component of the load, Fv is the vertical com ponent of the load, Lv is the distance from the vertical com ponent of the load to the fulcrum point, and d is the fixture diameter.[47-49]

Testing of the integrity of the abutment-implant connection could possibly be more realistic if a cyclic loading unit within a wet environment was used.[50]

However, this approach also presents certain disadvantages since it cannot accurately reproduce mastication, which is a very complex procedure influenced by age, gender, food texture, occlusal scheme, time, and presence of temporo mandibular disorders.[51]

In this study, abutment screws were tightened to 30 N-cm according to the manufacturer’s instructions with torque gauge. Application of the optimum torque to the implant–abutment complex is critical for long-term successful prosthetic implant restoration. Applied torque develops a force within the screw calledpreload. [23]

The result of this study shows that after applying two insertion torque with 10 min of interval before any loading leads to some torque loss. This finding matches previous studies that reported initial torque loss.

Ten-minute interval was left after the first torque application, and all screws were retightened to the same tightening torque (30 N-cm) with the same digital torque gauge to compensate for the preload loss due to settling effect of the screw thus ensure achieving optimal preload as only 10% of the initial torque is transformed into preload, where the remaining 90% is used to overcome the friction between the surface irregularities.[50]

Screw loosening is the most frequently occurring mechanical complication of implant restorations.[52] Abutment screw loosening has been reported in a large number of studies with an incidence ranging from 2% to 15% of abutments.[53] Screw loosening is caused by in adequate tightening torque, settling of implant com ponents, inappropriate implant position, inadequate occlusal scheme or crown anatomy, poorly fitting frameworks, improper screw design/material, and heavy occlusal forces.[54] To overcome screw loosening and joint instability, many technical solutions have been suggested. For example, new abutment screw designs and materials for maximizing preload, mechanical torque-applying instruments for optimizing tightening torque, precise implant components for anti-rotation, and internal conical connection implants with no micro motion or micro gaps have beenproposed.[55]

Cyclic loading can provide only a partial indication as to what may occur during mastication, by causing fatigue to implant components.[45-46] It should also be mentioned that more specimens and inclusion of additional implant systems and components are required for definite conclusions to be drawn, which in any case should also be confirmed by randomized control trials.

According to the results of this study, with increasing collar height after dynamic cyclic loading there was an increase in % of RTL. As the abutment collar length actas vertical cantilever, which act as a force magnifier. Due to this lever effect of cantilever design there is increase bending force on screws. Also the result shows removal torque loss ratio was increased significantly with increasing angulation of abutments.

Conclusion

Within the limitations of this in vitro study, the following conclusion can bedrawn.

a) Abutments having gingival collar height 2 mm shows less reverse torque values than 4 mm gingival collar height.

b) Angulated abutments having gingival collar height 2 mm shows less reverse torque value than 4 mm gingival collar height.

c) Screw loosening increases with increasing abutment angulation and collar height after 100,000 cycles of dynamic cyclic loading

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