Loss of torque with engaging and non-engaging abutment connections in a 3-unit screw retained implant fixed partial denture: An in-vitro pilot study

1. Introduction:

Screw loosening is one of the most common technical complications in implant dentistry.[1-3] The literature reports an incidence of screw loosening ranging from 5.5-13.7% for single crowns[1,4] on implants and 5.3-8.1% for implant-supported fixed partial dentures (FPDs) after 5 years.[2,4-6] Screw loosening increases the gap between implant components contributing to peri-implantitis and bone loss.[1,7]

At the same time, prosthetic instability caused by screw loosening can produce occlusal overload and can result in screw or implant fracture.[2]

McGlumphy et al[7] stated that the joint separating force and clamping force are 2 major forces determining implant screw tightness when the screw is used to secure the restoration to the implant. The screw becomes loose when the joint separating force is greater than the clamping force.[8]

When a screw is tightened by applying torque, it elongates and produces tension. This tension is called preload, a direct determinant of clamping force.[7,8] Preload is related to (1) applied torque,[7] (2) connection type and design,[7,9] (3) settling effect,[7] (embedment relaxation) (4) screw head and thread design,[7,10,11] and (5) material properties.[7,10-12]

1. Applied torque: The occlusal force on an implant-supported fixed prosthesis is concentrated in the coronal aspect of the implant at the implant-abutment junction (IAJ). Non-axial forces on the implant-supported prosthesis can create a force at the IAJ which may result in critical stress approaching or exceeding the preload. The stress at the IAJ can be based on the internal design of the connection, which in turn can affect the loss of preload of the abutment screw.

2. Connection type and design: The connection type is important in planning an implant-supported FPD. Various types of connections are available based on the implant system. Some of the differences are an external hex connection, i.e., the IAJ is above the platform of the implant or an internal hex connection, i.e., the IAJ is below the platform of the implant. Each of the these connections may have an IAJ, where the abutment connects to the implant either at only 1 surface of the IAJ, multiple surfaces of the IAJ or on all the surfaces of the IAJ.

   The commonly used type of connections are the engaging connection where all the surfaces / walls within the implant and the abutment are in close contact to each other or non-engaging where there is no contact between any axial walls of the implant or the abutment.[13] An engaging connection is used for a single-unit restorations to create a prosthodontically stable IAJ, whereas non-engaging abutments are used where multiple units are to be splinted together.[4,13] Various designs are presently available for the internal connection, which can be a hex, a spline, a hex with morse taper, an octagon with a combination of hex, and various others.

3. Settling effect (embedment relaxation): A significant mechanism that may result in loss of preload is the settling effect. The settling effect occurs because of wear or flattening of the microscopically rough high spots at the contacting surfaces between the threads on the screw and the internal threads of the implant.[7] Part of the applied torque is used to flatten the rough high spots and then as more torque is applied the screw elongates. All the screw elongates, the friction between the screw and implant will result in reduction of preload.[14]

4. Screw head and thread design: The fit of the screw head within the abutment also plays a role in the maintenance of the clamping force. A parallel sided head helps in maintaining the clamming force better then a screw head with a taper. The thread design, i.e., thread pattern and thread pitch may also have an effect on the maintenance of the clamping force.[12] In most of the abutment screws only the coronal 2-3 threads usually engage with the internal walls of the implant, which makes the decision to select the connection type more critical in order to reduce the stress on the abutment screw. The implant system used in this study, has a special thread design, Spiralock® (Biohorizons) which makes contact to the internal implant walls all along the length of the abutment screw.

5. Material properties: The choice of the abutment screw material has a direct effect on the potential loss of torque. Various materials, such as gold, titanium gold alloy and titanium alloy produce differences in torque.[12] The material properties are also related to the modulus of elasticity of the implant and the abutment screw.[3]

Torque and clamping force are closely related to each other in the linear elastic region. There is a linear relationship between the torque applied to a screw and the clamping force produced by the screw. This shows in experiments, like the one shown in Fig. 1a, measuring both the torque and clamping force as a screw is tightened. All dental implants are designed to work in this region.[15]

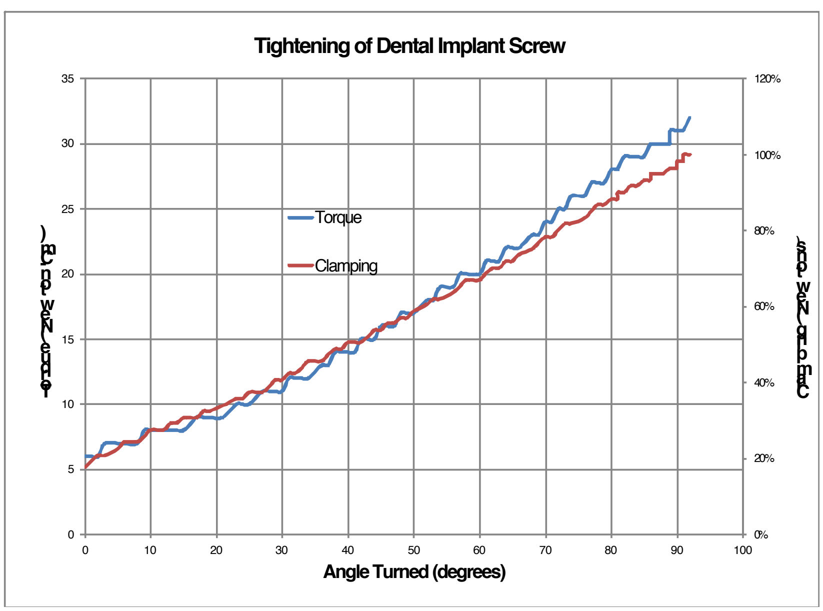

Fig. 1a: Tightening of dental implant screw

It can be seen that both the torque and the clamping force increase together. When the clamping force from this experiment is plotted over the torque results. (Fig. 1b)

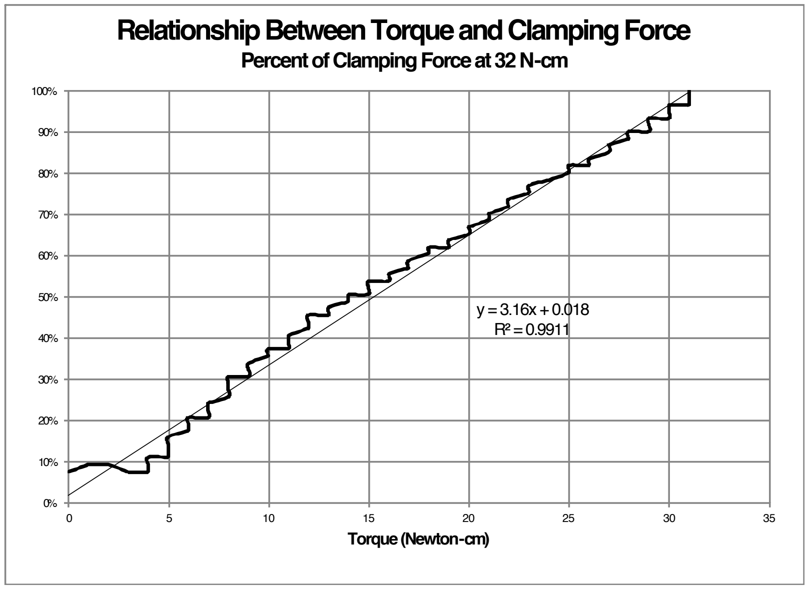

Fig. 1b: Relationship between torque and clamping force

The peak value is the clamping force at the 32 N-cm specified for this screw. The linear regression equation shows that the clamping force increases at the rate of 3.16% per N-cm. The R^2 value of 0.991 says that the equation is a good model for the relationship between torque and clamping force.[15]

The linearity of this relationship indicates that when torque audits are performed at the 20,000 cycle increments, a change in the torque results in a proportional change in the clamping force. If, for example, a 15% change had occurred since the last measurement, a 15% change in the clamping force had also occurred.

The design of this study was based on an engineering model, where the tolerance of the components are high and low standard deviations, hence the sample size is small.[21] The study by Burguete RL et.al. and Balfour A et.al., tested the importance of an hex using an equation in which the values obtained match the theoretical standard.[19,20] Mechanical analysis of the IAJ demonstrated that the load carrying capacity of the joint is increased and additional stresses in the abutment screw are decreased as a function of the hex height[20,22]:

$$Fs = \frac{2(P[H] - R2[h])}{D}$$

where Fs = load on abutment screw, P = lateral load on the abutment, H = height of abutment, R2 = reaction load of the implant hex on the abutment , h = height of hex and D = platform diameter of the implant.

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2. Aim:

To measure the residual torque in the abutment screws of a 3-unit FPD with 3 different IAJ designs: (1) 2 non-engaging abutments, (2) 1 non-engaging abutment with an engaging abutment, and (3) 2 engaging abutments, when the FPDs are loaded off-axis.

3. Rationale:

There is no scientific evidence for selection of a screw-retained or a cemented-retained FPD.[5,11] Unlike in cases where, there is a clear need for a screw-retained prosthesis, i.e., hybrid prosthesis or cement-retained prosthesis where the implant position is not ideal. With screw-retained FPDs, non-engaging abutments are commonly used, but the effect of this type of connection on the maintenance of the preload and screw-connection are not well understood.

The use of multiple engaging abutments with screw retained FPD is usually not possible because the implants are never perfectly parallel to each other. Consequently a combination of engaging and non-engaging abutments or all non-engaging abutment is required. The FPD is usually loaded non-axially, and with non-engaging abutments, much of the stress is concentrated in the abutment screw. The stability of the abutment screw in maintaining the torque could be dependent upon the type of engaging abutment and non-engaging abutment connection of a FPD. It is generally assumed that in the absence of an internal fit of the abutment, all of the torque forces from the off-loaded axis will be transferred to the abutment screw and may cause some embedment relaxation.[16]

The importance of the depth of the connection, i.e., the surface contact of the internal surfaces of the abutment to the implant, in the maintenance of torque, is not known.[17]

4. Null Hypothesis:

Null Hypothesis 1:
There is no difference in the loss of torque observed with any combination of engaging and non-engaging abutments.

Null Hypothesis 2:
There is no difference in the loss of torque observed with the non-engaging abutment when compared with the loading or the non-loading site.

5. Material and Methods:
5.1 Materials:

A total of 20 internal hex Biohorizons LaserLok implants (Biohorizons), 4.6 mm in width and 10.5 mm in length, with 20 stock abutments (3-in-1abutment, Biohorizons) and 30 abutment screws (Biohorizons) were used in the study. A torque angle signature (TAS) device (custom made, RSDM, USA) (Fig. 2) was used for measuring the loss of torque within the abutment screw. The margin of error for the readings of the TAS device were less then 1 Ncm. A 0.050” hex driver (Biohorizons) was embedded in acrylic resin (GC Pattern Resin) within a hex bolt head to be attached to the TAS. (Fig. 3)

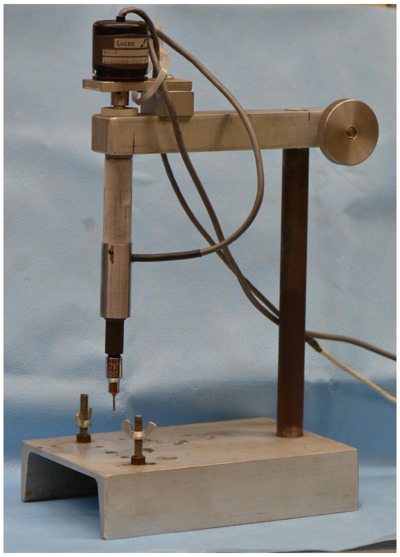

Fig. 2: TAS device

Fig. 3: 0.050” hex driver embedded in acrylic resin

5.2 Experimental Method:

5.2.1. Experimental Groups:

A total of 3 groups with 3 specimens per group were fabricated.
Group 2E: 2 engaging abutments (N=3)
Group 1E: 1 engaging abutment (N=3)
Group 0E: 0 engaging abutment (N=3)

	Loading Site 1 (SM)	Loading Site 2 (SPo)	Loading Site 3 (SPr)
Group 2E	Engaging Abutment	Load Site	Engaging Abutment
Group 1E	Engaging Abutment	Load Site	Non-engaging Abutment
Group 0E	Non-engaging Abutment	Load Site	Non-engaging Abutment

Table 1: Group and site distribution

5.2.2. Master specimen fabrication:

On a surveyor platform, 2 laboratory analogs were attached to 2 open-tray impression copings on the flat surface at an intra-implant distance of 15 mm. The impression copings were connected to each other with acrylic resin (GC Pattern Resin), which will act as a jig (Fig. 4a, 4b).

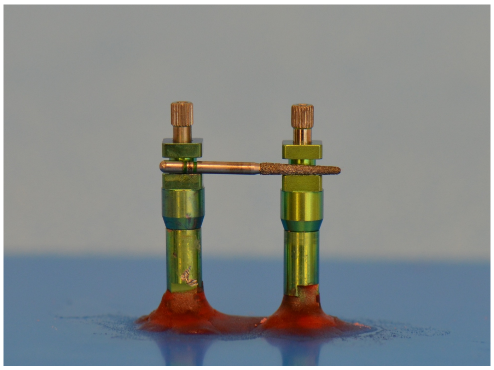

Fig. 4a: Lab analogs connected to a flat surface

Fig. 4b: Impression copings connected to each other

The jig was connected to an analyzing rod of the surveyor by using acrylic resin (GC Pattern Resin) (Fig. 5)
The entire assembly was placed on a surveying table, around which boxing wax was used to fabricate a box pattern in a dimension of 40x30x30 mm (LxWxH). The surveying table was angled at 25 degrees and the assembly was centered in the box (Fig. 6).

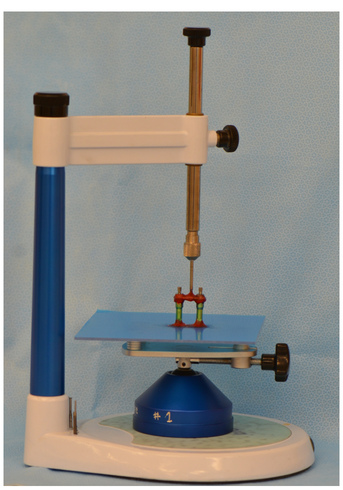

Fig. 5: Jig connected to surveyor

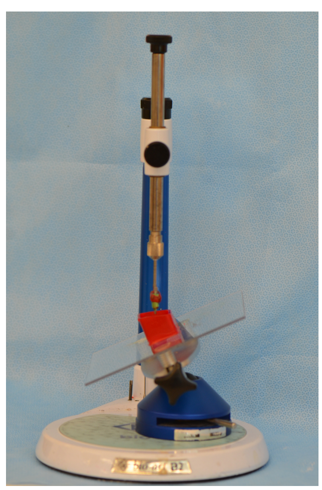

Fig. 6: Surveying platform angled at 25 degrees

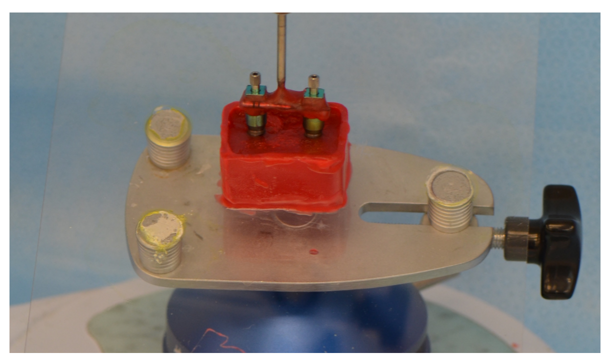

Fig. 7: Implants embedded in acrylic resin

Laboratory analogs (Biohorizons) were replaced with implants and acrylic resin (GC Pattern Resin) was poured into the box pattern (Fig.7)

5.2.3. Experimental specimens:

A custom tray with 5-mm relief, except for the base of the master specimen, was fabricated with light activated urethane dimethacrylate (Triad, Dentsply). An impression of the master specimen was made in heavy-body polyvinyl siloxane impression material (Aquasil, 3M ESPE) by using open-tray impression copings (Biohorizons, USA) with a custom tray (Fig. 8a, 8b).

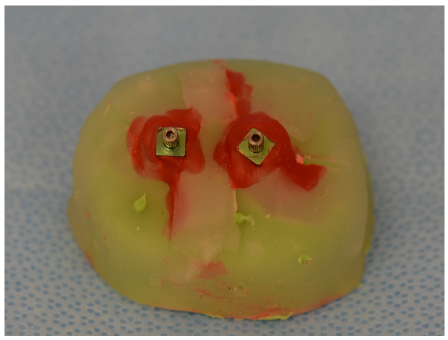
Fig. 8a: Custom impression tray - Top view

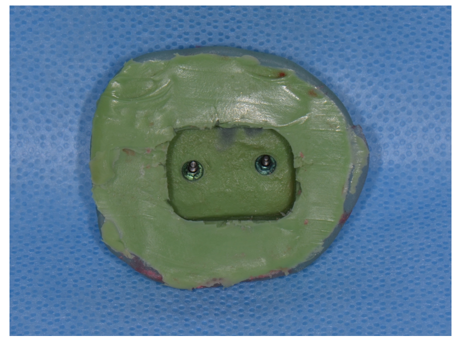
Fig. 8b: Custom impression tray - Intaglio view

Implants were connected to the open-tray copings with acrylic resin (GC Pattern Resin) and then acrylic resin (GC Pattern Resin) was poured into the impression.
Eight more experimental specimens were fabricated by using this technique. An additional specimen was fabricated for “staircase analysis”.

5.2.4. FPD fabrication:

The master specimen with 2 engaging abutments was used to fabricate a 3-unit FPD with occlusal access holes and a 25-degree cuspal anatomy that was cast with a noble alloy metal (Spartan Plus, Ivoclar Vivadent). The occlusal access holes were used for the purpose of torque audit.
Along the mid-buccal and mid-lingual surfaces, a reference mark was made to be used as a reference to assess the marginal adaptation. The fit of the FPD on the master specimen was verified with silicone disclosing material (Fit Checker, GC) and adjusted as necessary. The marginal adaptations was checked with an explorer before and after cementation for each specimen.

5.2.5. Mounting of Specimens:

The abutment screws were torqued to 30 Ncm and then to compensate for the preload loss caused by surface sinking, the tightening torque must be applied again 10 minutes after a new screw is fastened.[18] The FPD was cemented on the specimen with a self-adhesive resin cement (Rely-X Unicem, 3M ESPE, USA) and the access holes were cleaned. The FPD with the specimen was held under a bench press for 10 mins.

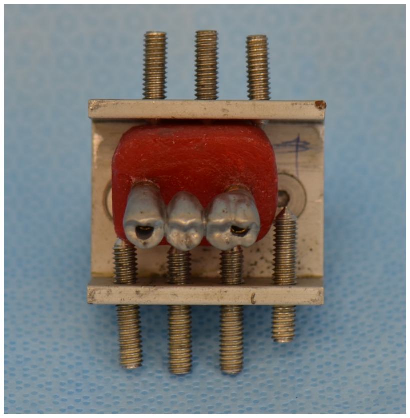

Fig. 9a: Specimen in custom holder assembly - Occlusal View

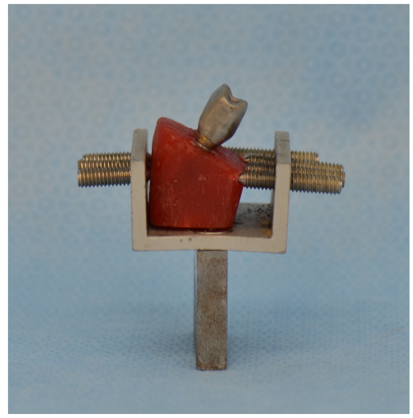

Fig. 9b: Specimen in custom holder assembly - Profile View

Post cementation, the margins were evaluated with an explorer subjectively to verify the adaptation. Each specimen had screws attached perpendicular to the acrylic resin base to hold the specimen in a custom holder assembly. (Fig. 9a, 9b)
The antagonist used for loading the specimen was a modified round-end 3/8" drill. The specimen was mounted on a universal testing machine (MTS 810, MTS, USA) with the custom holder assembly.

5.3 Experimental Protocol:

The specimens were oriented non-axially to the loading point, at an angle of 25 degrees on the slope of the palatal cusp.
Each specimen was loaded at 3 sites:
<u>Site 1 (SM):</u> #3 Molar
<u>Site 2 (SPo):</u> #4 Pontic
<u>Site 3 (SPr):</u> #5 Premolar

The loading protocol was finalized after performing a "staircase analysis".

5.3.1. Staircase Analysis:

Staircase analysis was conducted in order to determine the load and cycles that would result in changes within the abutments screw and assess how much load led to changes or failure in the experimental design. This was conducted by using 2 combinations of abutments (2 engaging abutments and 1 engaging abutment with 1 non-engaging abutment) with a load that ranged from 200N - 400N (200N, 250N, 300N, 350N, 400N) with frequencies that ranged from

1 Hz - 8 Hz (1 Hz, 4 Hz, 8 Hz) for a total of 50,000 cycles, with torque audit after every 10,000 cycles.

5.3.2. Torque Audit using TAS:

Torque audits are conducted to verify the amount of residual torque in a screw. A method of tightness verification called torque-angle signature analysis provides a very practical and powerful technique for evaluating the actual clamp force achieved by a screw tightening process. Examining the torque-angle signature of a screw basically means looking at tightening and loosening curves, or plots of torque versus angle, as the screw is installed/uninstalled. These curves are studied initially in the elastic-tightening region where the screw has not gone beyond yield.

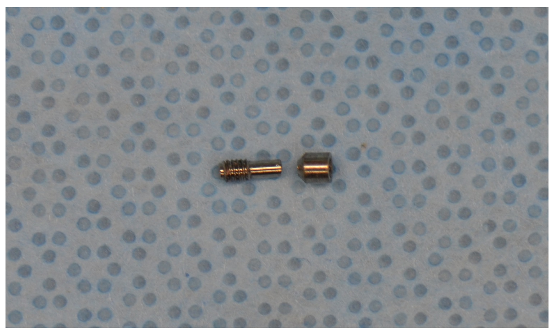

Fig. 10: Fractured Screw

Preliminary torque audit from the staircase analysis demonstrated fracture of the abutment screws (Fig. 10) in the non-engaging abutment group in the in the fourth & fifth

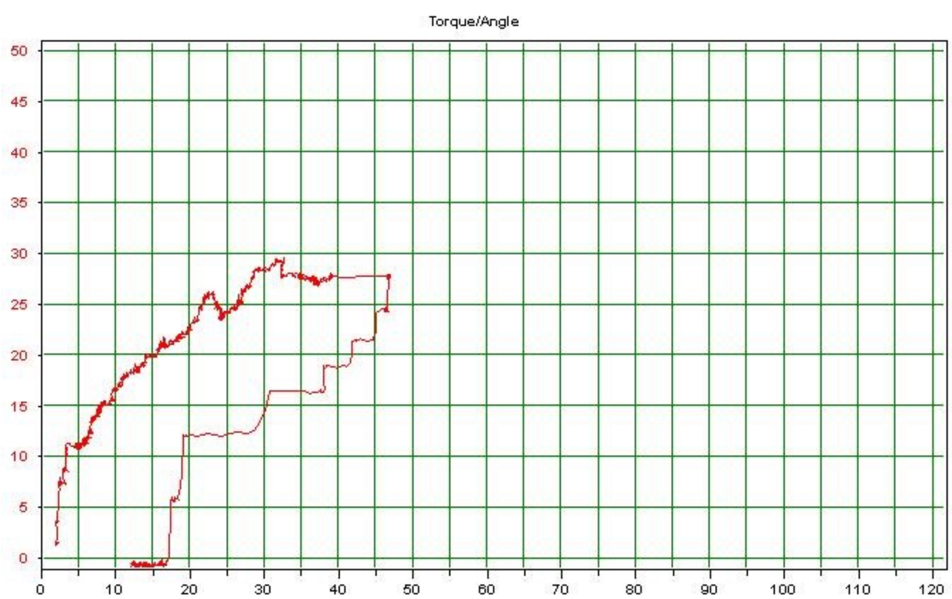

Fig. 11: Torque Angle Signature graph

cycles at a load of 400N with a frequency of 4 Hz. The data from the staircase analysis demonstrated changes in the fourth and the fifth cycles for both groups, which suggested that more significant changes would be observed if the number of cycles were increased. Based on the observations from the staircase analysis, the ideal amount of loading force and frequency simulating a clinical condition was decided.
The data from the TAS device was used to determine the loss of torque in the abutments screws. (Fig.11) The initial record of the torque on the vertical axis represents the residual torque within the screw. As the angle starts increasing along the horizontal axis, it represents re-tightening of the screw. From the graph the residual torque values were decided based on the when there is a proportional increase in the slope of the torque-angle signature angle of screw.

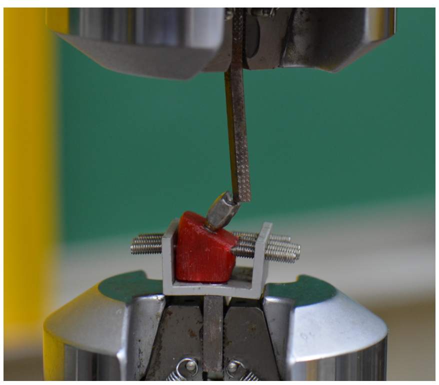

Fig. 12: Custom holder assembly in universal testing unit

Fig. 13: Engaging and modified non-engaging abutment

For the final testing protocol, each site was loaded to a cumulative total of 100,000 cycles at a load of 250N and a frequency of 8 Hz in a universal testing machine. (MTS 810, MTS, USA) (Fig. 12)
To develop non-engaging abutments (a butt joint), the hex of the engaging abutments was removed with a diamond rotary instrument. (6909DC.31.040 FG Coarse Wheel Diamond, Brasseler) (Fig. 13)

5.4 Experimental Analysis:

On each site, after loading every 20,000 cycles, loss of torque was measured for sites SM and SPr by using the TAS device.
The abutment screws were torqued[17] to the last measured preload value and this procedure was repeated every 20,000 cycles until a total of 100,000 cycles of load are applied. The same screw was used for the entire 100,000 cycles. The data from the study was objectively evaluated based upon the identified torque values. This approach was suggested by Alberto Cuitiño, PhD., Department Chair, Professor, Mechanical and Aerospace Engineering, Rutgers University.[21]

Data acquired from the study was evaluated as follows:

a) Is there a difference in the loss of torque value with the different types of abutments?
b) Is there a difference in the loss of torque value with each successive 20,000 cycles?
c) Is there a difference in the loss of torque value when load is applied at the 3 different sites?
d) Is there a difference in the loss of torque value with the non-loading site when compared with the loading site?

Non-parametric test Wilcoxon Rank test was used to evaluate the significance of the loss of torque values with each successive 20,000 cycles.

6. Results:

In the present study, the influence of engaging or non-engaging abutments on the loss of torque in the abutment screws of a 3-unit screw retained implant FPD was evaluated. Also the influence on cyclic loading, effect on different loading sites and their effects on the non-loaded site of the FPD were also evaluated.

a) Is there a difference in the loss of torque value with the different types of abutments?
A marked increase in the loss of torque with the non-engaging abutments can be observed in groups 1E (Fig.15b) and 0E (Fig.16b) as compared to group 2E. (Fig. 14b)

b) Is there a difference in the loss of torque value with each successive 20,000 cycles?
A non-parametric, Wilcoxon Signed Rank Test ($p<0.5$) was used to determine the loss of torque value with each successive 20,000 cycles. All 3 groups showed progressive loss of torque as the cyclic loading progressed to a total of 100,000 cycles. (Fig. 14-16)

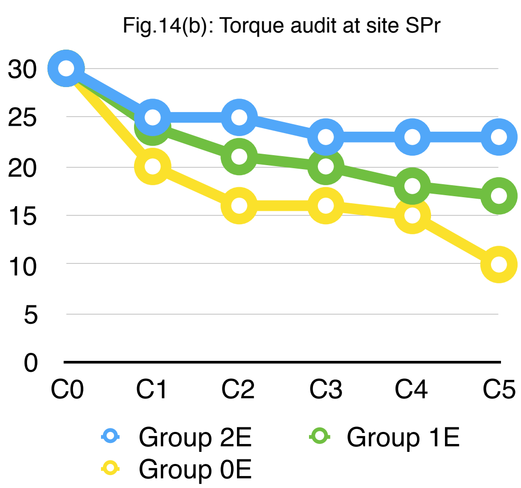

Fig. 14: Torque Audit when site SM is loaded.

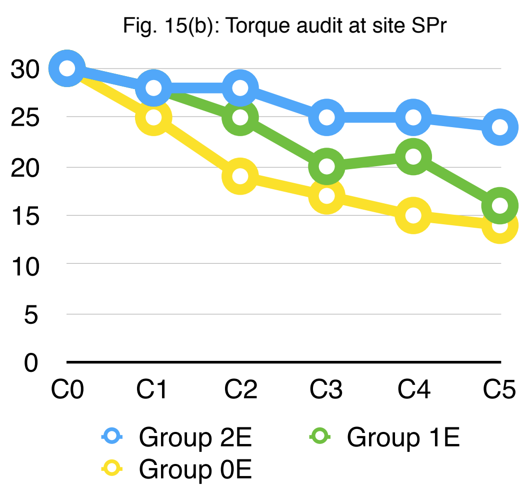

Fig. 15: Torque Audit when site SPo is loaded.

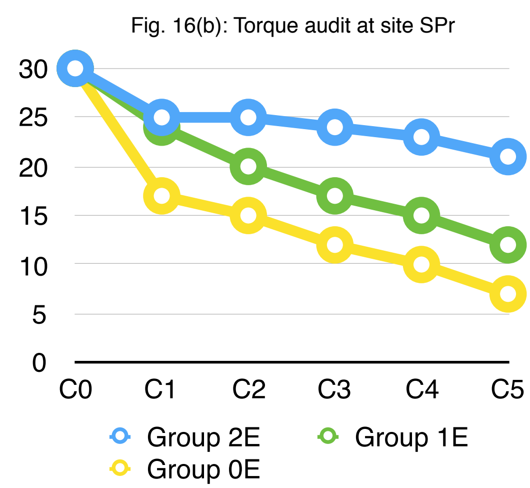

Fig. 16: Torque Audit when site SPr is loaded.

Fig. 14(a): Torque audit at site SM

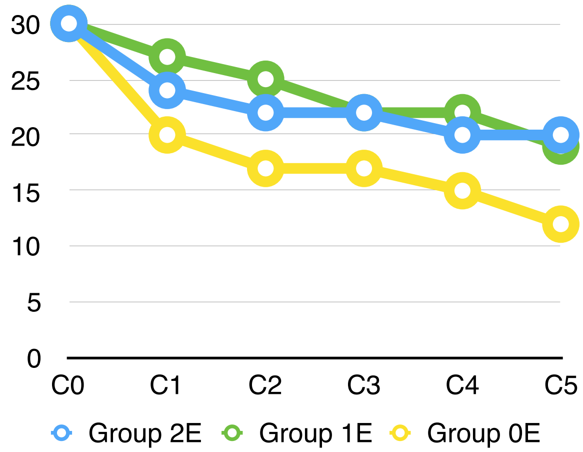

Fig.14(b): Torque audit at site SPr

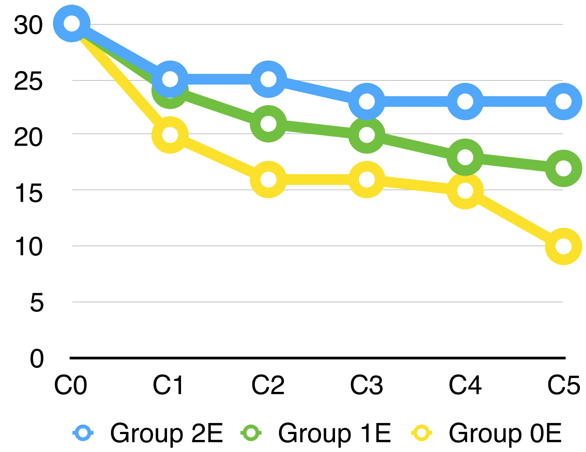

Fig. 14: Torque Audit when site SM is loaded.

Fig. 15(a): Torque audit at site SM

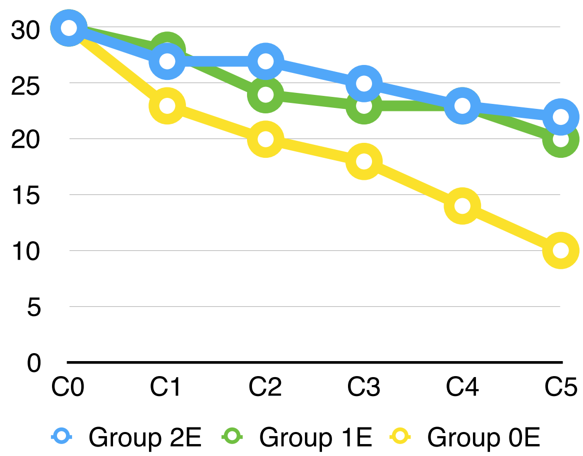

Fig. 15(b): Torque audit at site SPr

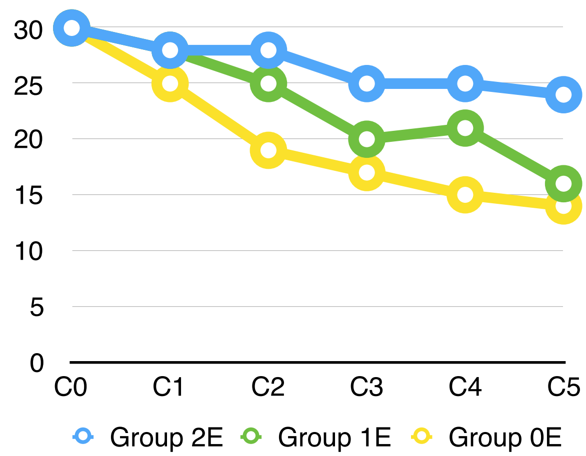

Fig. 15: Torque Audit when site SPo is loaded.

Fig. 16(a): Torque audit at site SM

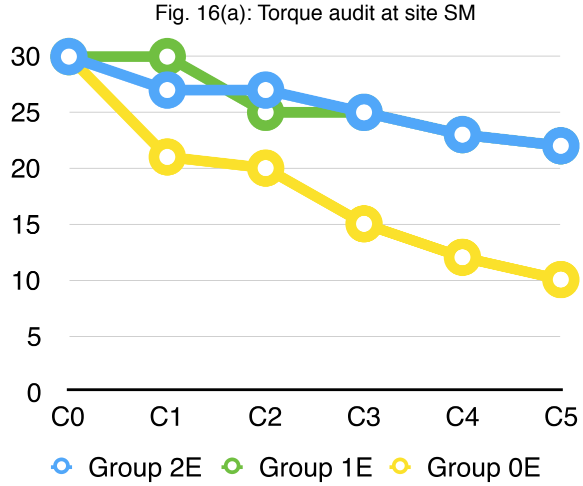

Fig. 16(b): Torque audit at site SPr

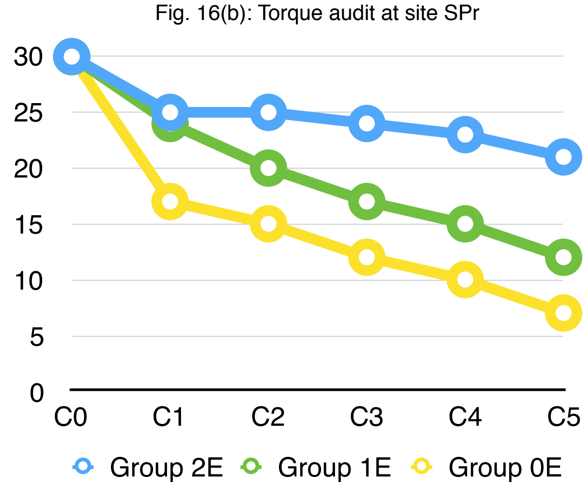

Fig. 16: Torque Audit when site SPr is loaded.

c) Is there a difference in the loss of torque value when load is applied at the 3 different sites?
The loss of torque when the load was applied at the 3 sites was evaluated. No difference in loss of torque was observed when the 3 sites were loaded within each group. (Fig.14-16, Table. 2)

d) Is there a difference in the loss of torque value with the non-loading site when compared with the loading site?
In group 2E and 0E, there was no difference in the loss of torque with the non-loading site when compared to the loading site. In group 1E, there was no difference in the loss of torque with the non-loading site when compared to the loading site SM, but there was a significant difference in the loss of torque for loading site SPr.

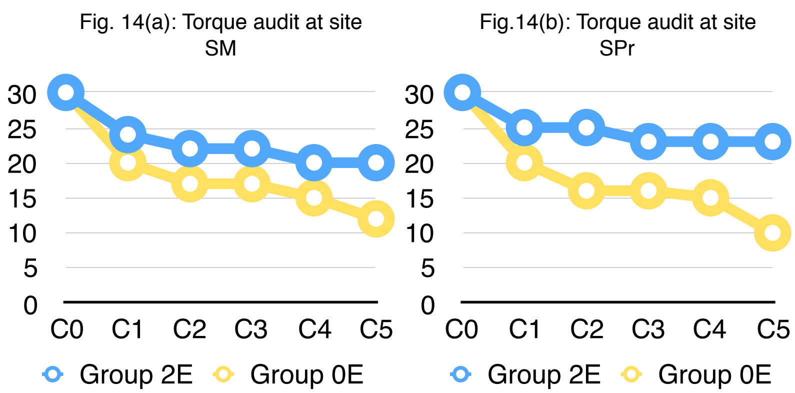

Fig. 14: Torque Audit when site SM is loaded.

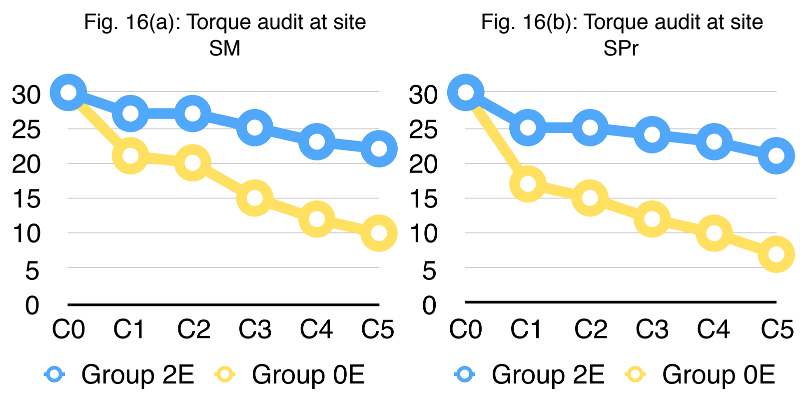

Fig. 16: Torque Audit when site SPr is loaded.

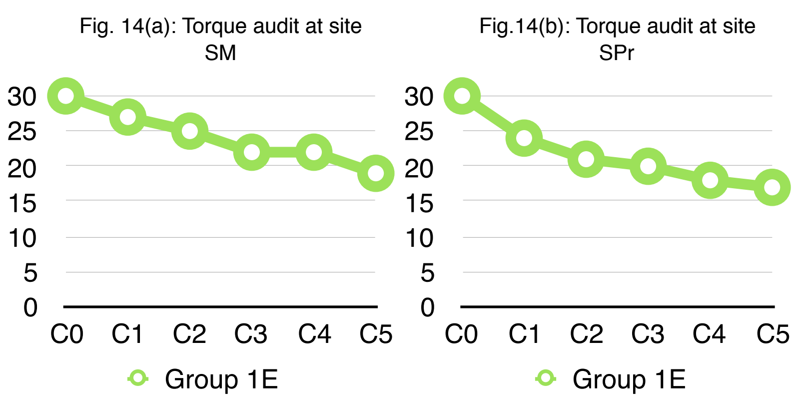

Fig. 14: Torque Audit when site SM is loaded.

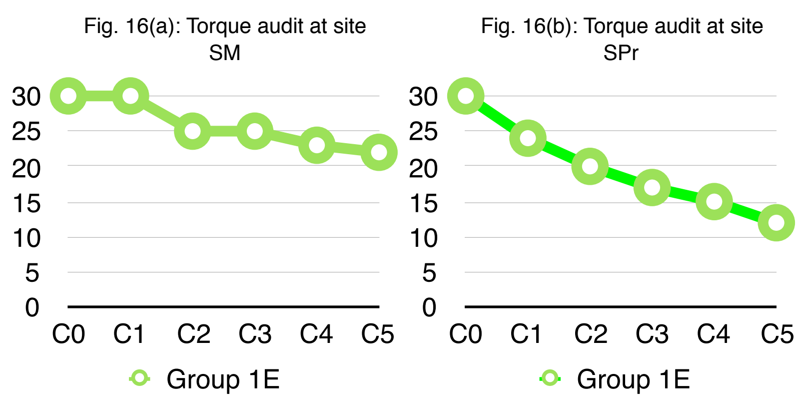

Fig. 16: Torque Audit when site SPr is loaded.

In the table 2, Site SM, SPo and SPr represent the sites where the load was applied. (SM/SPr) represents the sites where the torque was audited in the abutments screws when the load was on applied on sites SM, SPo and SPr in each group. For instance, in Group 2E at the end of cycle C1, when load was applied on site SM, 24/25 represents the residual torque in the abutment screws on site SM and SPr.

	CYCLE (N-cm)				
	C 1	C 2	C 3	C 4	C 5
Group 2E					
SM (SM/SPr)	24 / 25	22 / 25	22 / 23	20 / 23	20 / 23
SPo (SM/SPr)	27 / 28	27 / 28	25 / 25	23 / 25	22 / 24
SPr (SM/SPr)	27 / 25	27 / 25	25 / 24	23 / 23	22 / 21
Group 1E					
SM (SM/SPr)	27 / 24	25 / 21	22 / 20	22 / 18	19 / 17
SPo (SM/SPr)	28 / 28	24 / 25	23 / 20	23 / 21	20 / 16
SPr (SM/SPr)	30 / 24	25 / 20	25 / 17	23 / 15	22 / 12
Group 0E					
SM (SM/SPr)	20 / 20	17 / 16	17 / 16	15 / 15	12 / 10
SPo (SM/SPr)	23 / 25	20 / 19	18 / 17	14 / 15	10 / 14
SPr (SM/SPr)	21 / 17	20 / 15	15 / 12	12 / 10	10 / 7

Table 2: Actual Data from the testing.

The data from this study suggests, the difference in the loss of torque when the non-loading site was compared with the loading site is marked. The non-engaging abutment when loaded off-axis showed greater loss of torque as compared to the non-loaded site with an engaging abutment. This suggests that the internal architecture of the abutment has great influence on the maintenance of preload.

	2E	1E	0E
SM	~33%	~37%	**~60%**
SPr	~30%	**~60%**	**~77%**

Table 3: Summary of loss of torque in percentage

In table 3, a summary of the percentage loss of torque is summarized. It can be observed that in any situation where non-engaging abutments were used over 60% reduction of torque from initial torque of 30 Ncm was noted. Contrary to that the engaging abutments demonstrated a little over 30% loss of torque was noted.

7. Discussion:

In this study, the Null hypothesis-1 is rejected because the loss of torque is observed with any combination of engaging and non-engaging abutments. Groups 1E and 0E showed a greater reduction in the torque at the site of the non-engaging abutments at the completion of cyclic loading as compared to group 2E. The loss of torque observed with the non-engaging abutment occurs due to lack of shielding for the abutment screws when the forces are applied in off-axis. The load applied on the FPD is transferred to the screw which creates more Hoop stresses within the IAJ and results in loss of torque at a greater rate than in engaging connection.

The observations from this research where the non-engaging abutments showed a greater decrease in the torque was similar with the findings from other publications which studied the stresses on abutment screw with external hex connection and internal hex connections for single unit crowns.[10,13,19-23] These findings can be attributed to the depth of the connection, design of the connection, screw thread surface, material properties.[10,13] The influence of internal architecture of the engaging abutment has been shown to have less stress on the abutment screw when the abutment is torqued as compared with butt joint abutments.[23]

Boggan et.al.,[22] evaluated the use of an external hex connection with a 1 mm hex height and developed a mathematical equation to justify that the depth of the connection is critical in reducing the stresses on the abutment screw. Other authors studied the external hex configuration and they suggested that the purpose of a hex is to determine the rotational position of the crown, not to absorb any lateral loading forces. The axial preload on the abutment screw is a determining factor for stability of the connection.[19,24]

The screw alone secures the abutment under axial loading as there is no form of engagement or reaction force by the external hex. However in the case of non-axial loading of the engaging abutment,the additional reaction from the hex gives additional resistance to the forces which will help minimize long term bio-mechanical complications. The internal architecture of the IAJ, as described by Chee W et al.[16] proves that in the external butt joint connection type, the stress caused by the external functional loads, is all applied to the screw. Whereas, in the internal-conical connection type implant system, the tightening torque produces wedge effect due to the conical abutment seating, and the load is mainly supported by the internal slope of the fixture. Thus the stress in the abutment screws is distributed through larger area reducing the stress in the screw when compared to the screw in the external butt joint.

Keeping in mind the lower resultant stresses at the IAJ with the use of engaging abutment, the use of cement retained FPD over implants with engaging custom abutments reduces the prosthetic complications. Zarb et al.,[25] and Hobo et al.,[26] described the errors related to fabrication of an implant supported FPD. A screw retained prosthesis as compared to cement retained prosthesis has a lower tolerance for error due to the use of die spacer in a cement-retained FPD. A poorly adapted screw-retained FPD can be one of the primary causes for screw loosening and/or fractures, which has been stated in the literature.[27-36] Another complication attributed to framework misfit is implant fracture. It is an uncommon yet significant complication that represents about 1.5% of restored implants followed for a period of 3 to 15 years.[31,37-39] Most of the fractures occur between the third and the fourth implant screw thread,which corresponds to the last thread of the fastening screw.[40]

The prosthetic complication rate in a full arch restoration for screw-retained or cement-retained prostheses was found to be very similar based on the systematic review by Sailer et.al.[2] The importance of the engaging abutment is less critical when full arch restorations or long span implant supported FPDs are fabricated as these prostheses have cross-arch stability from the tripodal effect relative to the anteroposterior spread.[2]

The preference for using a screw-retained prosthesis is retrievability and the absence of residual cement around the IAJ.[5,41] These factors can be overcome by using engaging custom fabricated abutments to maintain the abutment-crown interface close to the free gingival margin thus maintaining optimal esthetic outcomes. The factors that influence the retention and resistance form for the superstructure are the same as for natural teeth.[42-45] The cement most commonly used with implant prostheses are provisional cements, as there is no risk of caries and they are much weaker then definitive cements. The removal of excess cement is more predictable when custom abutments are designed properly following the prosthodontic principles and the use of provisional cement for retrievability, thereby balancing the biological and prosthetic complications.

Null hypothesis -2 was rejected as their was a marked difference in the loss of torque when the non-engaging abutment was loaded off-axis as compared to the non-loaded engaging abutment. These findings are consistent with previous studies. [19-23]

Occlusion also affects the selection of the restoration type - screw-retained or cement-retained. Ideally, in the case of posterior teeth, an implant should be placed in the central fossa for an axial loading to be generated. The occlusal table of the aforementioned teeth is about 4.5 mm for the premolars and 5 to 6 mm for the molars. The heads of fastening screws have a diameter of about 3 mm, thus requiring the screw access hole diameter to be at least 3 mm. This 3 mm diameter represents 50% of the occlusal table of the molars and more than 50% of the occlusal table of the premolars.[4,46] The establishment of ideal occlusal contacts in screw-retained prostheses may not be possible because the screw access hole occupies a significant portion of the occlusal table. The access holes are sealed with composite, which tends to wear out over time, which causes unstable occlusal contacts.[47] Ideal contacts can be maintained with cement-retained prosthesis over a period of time.[47] If ideal contacts are not maintained, there is a higher chance of screw loosening, screw or implant fracture due to instability in occlusal contacts.

7.1 Limitations of the study:

In this study only one type of internal connection which had a slip fit connection, i.e., hexagon was studied. Also the FPD was cemented on the abutments, which could introduce an additional junction leading to errors in microns.

8. Conclusion:

Within the limitation of this study the following conclusion can be drawn:

a) The use of a non-engaging abutment causes a greater loss of torque when compared to an engaging abutment in all groups.

b) There is a consistent reduction in torque when the FPD in cyclic loading.

c) Loading a non-engaging abutment has greater influence on loss of torque when compared to an engaging abutment.

8.1 Future Studies:

Additional studies should be conducted to assess the loss of torque in similar clinical scenarios with a combination of a non-engaging abutment and engaging abutment with a 3-unit implant-supported FPD when the surface of the abutment screw is modified with various surface treatment or with use of an intermediary gels/solutions. Studies evaluating different internal architecture, i.e., conical connection, conical connection with hex, trilobe, octagonal design should be conducted to assess if the internal architecture of the IAJ has any greater influence on the loss of torque.

8.2 Clinical Significance:

The presence of an anti-rotational element in a FPD is critical in reducing the stresses on the abutment screw. For short or long span FPD the role of an engaging abutment is to reduce the instances of prosthetic complications like screw loosening or fractures. For cement-retained or screw retained prostheses, the passivity of the framework is important in order to reduce the stresses on the hex and the abutment screw when non-axial forces are applied. Also the use of third party parts should be avoided as the mating surfaces are not milled to the precision of the original manufacturer. The use of an engaging abutment should be considered when designing a prosthesis, in order to reduce the prosthetic complications.

Loss of torque with engaging and non-engaging abutment connections in a 3-unit screw retained implant fixed partial denture: An in-vitro pilot study

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