Original Article

To Review the Effect of Tightened and Loosened Torque on Two Different Implant–Abutment Connection Designs: A Scanning Electron Microscope Study

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Abstract

Introduction: It is crucial to take care of stability between various implant parts for the general success rate of the reconstruction. Component fit, saliva contamination, machining accuracy, and screw preload influence the steadiness of implant–abutment connection. Loosening of abutment screws has been a well-known technical problem. **Aim:** The aim of this study was to gauge repeated tightening and loosening torque on two commercially available implant/abutment connection designs. **Study Design:** This was an *in vitro* study. **Methodology:** A total of 32 implant analogs samples using a metal die with, metal ring of 20mm x 20mm x 20mm in size and a hole in the center were prepared. For both the groups, the implant analog was axially threaded within bases. They were clasped at an edge parallel to the standard minimal bone position. A 35 N/cm torque was enforced, each implant and abutment connection in both the groups using toque ratchet. After 20 min, screws were loosened and detorque measurement was recorded up to ten times. Scanning electron microscope micrographs of selected screws also are presented. SPSS (21.0 version) was used for analyzing data. **Results:** The mean residual torque for Group 1 was − 51.45 and Group 2 was − 43.29. The RTq (%) was found to be significantly less (0.028*) among Group 2: conical connection as compared to Group 1: butt joint connection. **Conclusion:** The loosening torque was significantly less in conical connection as compared to butt joint connection.

Keywords: Internal hexagonal connection, implants, residual torque

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Introduction

For the previous couple of 100 years, replacement of absent teeth using implant analogs has been a part of implantology. Dr. P-I Brånemark alongside his coworkers discovered coincidentally that steady liking between living bone and titanium oxides which they named as osseointegration. This implied research leads into another era of rehabilitative dentistry.[1]

Implants provide an alternative fixed rehabilitation of edentulous areas. Despite achieving great success with implant rehabilitation, failures are usually encountered, especially with single restorations. Technical complication occurs at the screw connection link between abutment and implant alongside screw joint loosening.[2]

On tightening the screw joint, contact occurs between the implant and abutment. The tightness of screw connection is directly proportional to the contact point between the connecting surfaces, which ends up in escalating resistance of the screw to the extrinsic loads.

The connecting area is partially governed by the endurance within the parts when fitted. It has been discerned that the larger areas are correlated with minimum screw slackening.

Initially, the implant designs employed only the extrinsic connection linking implant body and therefore the support; intrinsic connection was introduced to this assembly so as to

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decrease screw loosening (SL). They provided an in-depth contact area and it also facilitated the restorative procedures.

Procurement of sound fit joining the parts of this assembly: implant also as abutment link provided stability and diminished micromovement at the joint.[3]

Requisite for a biomechanical argument in reference to prosthetic redesign on the implants is very expertly accepted. It takes into contemplation the unit of implants to be placed, location of implant sites, alongside cantilever forces. Despite this, constituent unclasping and splintering carry on to be a matter of distress till date.[4]

Stability between different parts the implant connection is crucial for its success. This is often highly important for single-tooth restorations, where accomplishing a strong interlink among the assembly is essential.[5]

Numerous propositions are given for connecting the implant–abutment to the implant body. There is variation within the systems with reference to their geometrical design, quality of materials used, and therefore the overall screw mechanics. Aside from this, component fit, saliva contamination machining accuracy, and screw preload also affect the implant–abutment connection stability.

The *in vitro* research suggests that the intrinsic connections are mechanically sturdier as compared to extrinsic plane (hex-type) connections. They further state a technical problem of loosening of abutment screws, which occurs within the initial first 2 years after delivery of the crown, amid the "classic" extrinsic-hex implant connection.

Improvement inside the stoutness of the extraneous implant–abutment relationship was earned by amending the screw compound, screw surfaces aboard duplicating real force values so on produce lofty commencing preloads.[5]

Degree of micromovement alongside the accuracy of fit among components and therefore the applied reinforcing torque influences mechanical stability on implant–abutment connection.

In tapered connection, the tightening torque elevates frictional interconnection and also sustaining implant–abutment prosthetic attachment. Hence, the higher the tightening torque, the more the achieved preload, hence the more stable the implant/abutment attachment. For accomplishment of implant aiding restorations, abutment screw joint steadiness and resultant implant–abutment attachment steadiness are important. Hence, the recommended constructor's strengthening torque might not always be same because of different clinical circumstances. Hence, it is necessary to contemplate that the steadiness of tapered joints could even be accomplished with a deescalating abutment strengthening torque than suggested by the constructor.[6,7]

The present research was conducted with an aim to gauge repeated tightening and loosening torque on two commercially available implant/abutment connection designs.

Null hypothesis

The torque loss after succeeding tightening-loosening cycles is a smaller amount in conical connection than the butt joint connection.

Methodology

The sample size was calculated using G Power software (version 3.0.10). Supported the calculated effect magnitude of 0.88, 5% marginal error, 95% confidence level, and 80% power of the research. The least possible sample size for the research is 16 in each group, a complete 32 samples.

Analog preparation

In total, thirty-two implant analogs were prepared.

They were allotted to two groups, namely:
1. Group 1: 16 internal hex butt joint connection
2. Group 2: 16 internal hex conical connection.

A metal die was first fabricated for placement of implant analog within the center of the acrylic block. This metal die consisted of a platform for the location of metal ring which was 20 mm × 20 mm × 20 mm in size and contains a hole, which holds the implant analog within the center of this metal ring. For both the groups, implant analog was axially threaded within the bases. They were clasped at an edge parallel to the traditional marginal bone level. Autopolymerizing acrylic (powder and liquid) was blended as per the manufacturer's instructions, and this acrylic in flow consistency was poured into the ring, which was left undisturbed for complete setting. After it had been completely set, die was far away from it.

Initially, each corresponding abutment was hand linked to the implant analogs of both the groups with no torque applied. Prosthetic key was securely linked to the connecting screws. The torque measuring instrument was held in such an edge in order that prosthetic key was securely linked to the connecting screw. Using toque ratchet, a 35 N/cm torque (according to the manufacturer's instruction) was enforced to every implant and abutment assembly in both the groups. After 20 min, screws were loosened and detorque measurement was documented. This cycle of tightening and loosening was finished ten times to every implant analog/abutment assemblage. The prosthetic ratchet was simultaneously adjusted to the implant/abutment assembly. Along liberating torque measurements. The recording for both the groups was documented.

Statistical analysis

Data were normally distributed as tested using the SPSS (21.0 version, IBM Corp, Armonk, NY) Shapiro–Wilk W test (*P* value was quite 0.05). Descriptive data were reported for every sample. Therefore, research was conducted using parametric test "independent *t*-test" (for contrasting two independent groups). Extent of statistical importance was set at *P* value (>0.05). This *in vitro* research was done to measure loosening torque (RTq) of two sorts of implant/abutment connection design. Loosening torque of two types of implant/abutment linking design was calculated using the subsequent formula:

RTq (%) =100 (RTq10 − Rtq1)/Rtq1.

(Mean and standard deviations of residual torque [RTq] from initial torque [ITq] after repetition of initial torque application ten times): (RTq-1 to RTq-10).

The intial torque used was as recommended by the manufacturer: (ITq: 35 N).

More than one reading was recorded to attenuate the error.

Results

The mean residual torque for Group 1 was − 51.45 and Group 2 was − 43.29, as shown in Graph 1. The RTq (%) was found to be significantly less (0.028*) among Group 2: conical connection as compared to Group 1: butt joint connection [Table 1].

The loosening torque (RTq) is described because of the torque needed for loosening a screw. Manufacturer's recommended initial torque was used (ITq: 35 N) for both the groups [Graph 2].

Scanning electron microscope results

Scanning electron microscope (SEM) micrographs of selected screws are presented. As a rule, it alright could also be seen that even an exactly machined new screw was not profoundly smoothed. In any case, SEM micrographs after 5 I/R cycles demonstrated a smoother surface of the peaks and vanishing of the knobs of the roots. Conversely, after 15 cycles, a kind of desquamation of the shallow layer was seen in some incline regions. Surface investigation for screw head showed that the corner fringe of the hexed opening was bit by bit adjusted because the test additionally continued. SEM examination after stacking likewise showed more annihilation of the string surface. Furthermore, even on another screw, a couple of pieces that had potentially been confined from the past screw might be basically recognized [Figures 1-4].

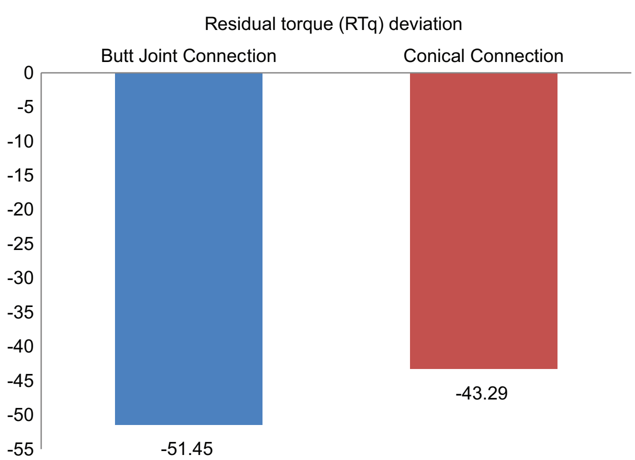
Discussion

The last three decades across the world have seen overwhelming advancement in modern implantology. Rehabilitation with osseointegrated titanium implant has been the mainstay of treatment for partially or completely edentulous patients.[7]

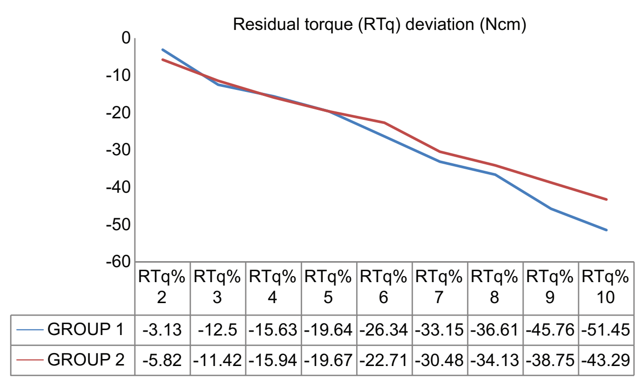
Initially, "osseointegration" was solely the standard considered for implant success. Eventually with increase demand of quality by the patients, implant dentistry focused on simplifying the tactic and decreasing the time of therapy . The implant dentistry focuses on simplifying the tactic and decreasing the time of therapy both for the patient and the implantologist. Dental implants have undergone various modifications and changes in their design so as to achieve functional as well as esthetic success.[7]

The literature documents several studies which have explored and discussed: biological aspects in context to the surgical procedures, restorative principles that determine the result also as prognosis of the implant restorations, and the implant–abutment interface dynamics.[8,9]

Implant failures such as soft-tissue defect or biomechanical



Graph 1: Mean and standard deviations of residual torque from initial torque after repetition of initial torque application ten times are shown above (residual torque-1 to residual torque-10) for Group 1 and Group 2



Graph 2: Residual torque deviation from initial torque after repetition of initial torque application ten times (residual torque-1 to residual torque-10) is shown above. Manufacturer's recommended initial torque was used for Group 1 and Group 2

Table 1: Comparison of mean residual torque among two groups

Levene's test for equality of variances		Equality of means (*t*-test)					
F	**Significance**	***T***	**df**	**Significance (two-tailed)**	**Mean difference**	**SE difference**	**95% CI of the difference (lower-upper)**
5.007	0.033	−2.314	30	0.028*	−8.15875	3.52646	−15.36075-−0.95675

Independent *t*-test, level of significance set at $P<0.05$. CI: Confidence interval, SE: Standard error

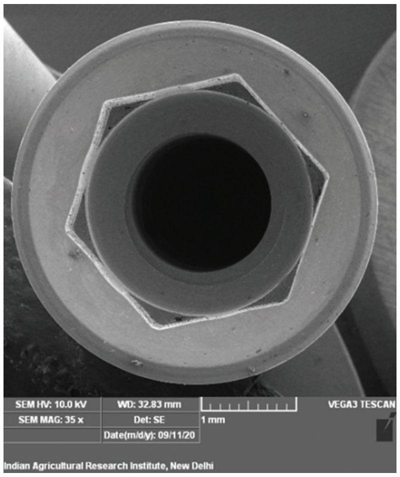


Figure 1: Sem image before cycling tightening and loosening torque in butt joint connection

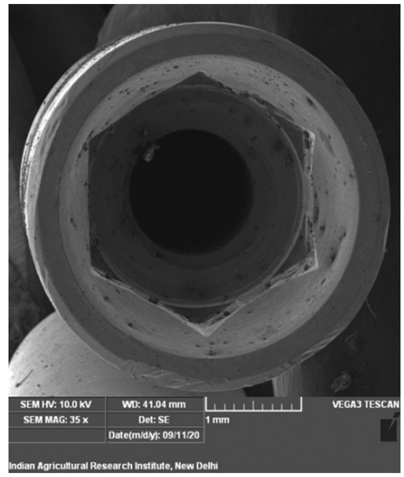


Figure 2: Sem image after cycling tightening and loosening torque in butt joint connection

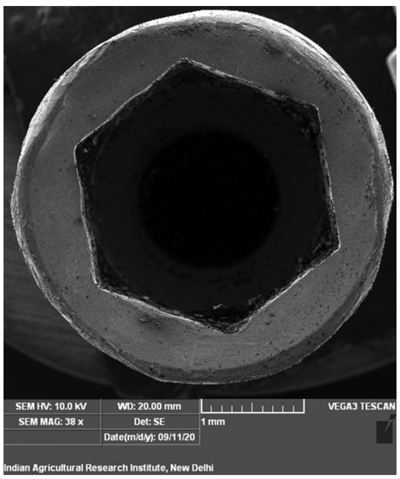


Figure 3: Sem image before cycling tightening and loosening torque in conical joint connection

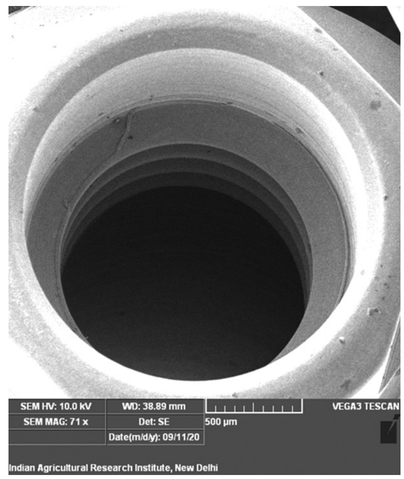


Figure 4: Sem image after tightening and loosening torque in conical butt joint connection

failures: loss of integrity and failures related to implant position have also been documented within the dental literature.[10,11]

These researches unanimously project toward the location where the implant body connects to the abutment and restoration, commonly referred to as implant–abutment connection interface as an important attribute to contemplate when choosing an implant system.

The right decisions taken while finalizing the implant–abutment assembly can improve esthetics and prognosis by structurally providing a secure joint. This prevents biological issues like peri-implantitis related to the treatment procedure. The steadiness of the implant–abutment connection both laterally and rotationally further governs the general prosthetic stability of the implant-supported restoration.[12]

The implant–abutment joint plays a pivotal role in maintaining the biomechanical properties. The strength of this assembly indicates whether it can resist the occlusal load, whether the rigidity focuses toward diminishing the micromovements. Implant–abutment assembly is externally and internally supported their well-defined projection. When the distinct projection is extrinsic to the implant body, it is referred to as external, and when it is recessed into the implant body, it is referred to as internal.

This assembly is often characterized as slip-fit joint, where a minor space is there between both the mating parts and therefore the joint is passive, also referred to as friction-fit joint, where between the mating parts no space exists and therefore the parts are forced to hitch together. The connection space of the matching surfaces is determined as butt affiliation and it's 2 flat surfaces touching each other perpendicularly and surfaces angled either internally or outwardly. The surface connection can also include a spinning resistance, lateral balancing geometry, and an assortment feature. This geometry is of varied types such as conical, cylindrical, hexagonal, octagonal, and hexagonal.[14]

When selecting associate implant system, 3 essential issues relate to first is the mechanics, second is biology and third is clinical utility t is evident that a close relationship exists between these factors.[15,16]

Conventionally, Brånemark's external polygonal shape was principally used, however their square measure complications associated with it, i.e., loosening of the screws of the abutment, rotational super misfit at the implant–abutment joint thanks to masticatory forces, and microorganism penetration have led to changes within the external hexagon, with the adventl of internal implant–abutment assembly.[17]

Internal implant–abutment connections begin to beat the clinical complications related to external connections. The aim of this new design was to enhance connection stability everywhere the location and functional periods and to untangle the armamentarium necessary for the clinician to finish the restoration.[18,19]

Stability and reliability are important prerequisites for future success of implant in implant–abutment connection. The first factor for stability is attachment of the abutment to implant by a threaded system. Henceforth, for our study, implant system with internal hex joint was employed.[20]

Very frequently six-point internal hexagonal connection is employed. This comprises a hexagon depressed into the implant body. The geometry is hexagonal internally, on to which the abutment fits at every 60° of rotation, but not at in-between angle. Contact area in between the implant–abutment connection is increased by internal hexagonal connections, which helps in load dissipation along with providing greater stability.

The screw joint stability is governed by three factors: first, the adequate amount of preload; second, the precision of the fit of the implant components; and finally, the antirotational feature of the implant–abutment interface. The right torque, when applied to the implant screw, gets translated into the preload, liable for holding the components together.

SL is extremely often encountered when doing implant placement. The fit of both the abutment and the screw within the internal taper of the implant along with tightening torque governs the steadiness of this assembly.[21-24]

SL and reduction in joint preload below a intensity result in the joint instability micro gaps if present any can also cause the fracture of the implant body or maybe the prostheses.[20]

The micromovements generated while the SL process initiated a pumping effect for the invasion of microorganisms which causes damage to the encompassing tissues and bone.[25]

Henceforth, SL may be a warning indicator of inappropriate biomechanical design alongside or without occlusal overloading, affecting the prognosis of the implants.[26]

For evaluating SL, this *in vitro* research was administered to assess the effect of torque removal on screws after simultaneous tightening and loosening cycles of the two different commercially available implant–abutment connection designs. The focus of this analysis was to match the implications of continual modification and loosening of implant/abutment affiliation thus directing advise in context of upper connection design.

It is already documented in the literature that the conical connection implants have superior mechanical stability. The taper connection provides "platform switching" in between endosseous implant and therefore the components of the abutment. At the level of the connection, the dimension of the abutment is a smaller amount than the diameter of body of the implant prosthesis. This provides another factor for the optimal protection of the peri-implant soft-tissue and grants the formation of a tissue collar overlaying the bone–implant interface.

Furthermore, the conical implant–abutment connection helps in forming a healthy biological width because the area connecting implant shoulder and abutment is not displayed on the peripheral contour of the bone; this might decrease bone loss.[27-29]

The result of this study depicted that conical interface showed superiority over butt joint design and supported the very fact that conical portion of interface in implant/abutment connection internal hex conical joint is in a position to soak up vibrational and functional load and further acts as a buffer.

Shortcomings of this research were that the prescribed torque of 35 N/cm was utilized in the study. Variations of this prescribed torque could have helped in understanding the prevalence of the implant designs. Second, a more sensitive instrument, i.e., scale utilized in assessing the loosening torque (RTq%), should be explored in future researches. Third, this was *in vitro* study; *in vivo* studies got to be executed to affirm the findings of this research.

Conclusion

From this study, it had been observed that the loosening torque was significantly less in conical connection as compared to butt joint connection, and the conical interface showed dominance over butt joint design because the internal hex conical joint was capable of absorbing vibrational and functional loads. The upper firmness of intrinsic connections, specifically the conical one, is significant as this furnishes the expected rehabilitation with outstanding durability and success outcomes. This joint yield superior resistance at interface of implant/abutment assembly allows antirotational attributes and resists SL.

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Conflicts of interest

There are no conflicts of interest.

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