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“Screw Loosening among Different Angles of Dynamic Abutments”

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Abstract

Purpose: The purpose of this in-vitro study was to evaluate and compare the removal torque values of dynamic abutment and multi-unit abutment. Specifically, 17-degrees angulated abutment and straight abutment of each type.
Problem: Components have been introduced that enable an implant crown's screw channel to be inclined lingually and the screws to be tightened in a non-axial orientation relative to the implant. There is a dearth of information on how the removal torque value (RTV) compares to that of ordinary screws.
Method: A total of eight internal hexagonal implant fixtures and abutment will be used in the study. Group A, B will be straight and angulated multi-unit abutment. Group C, D will be straight and angulated dynamic abutment. Removal torque value well be assessed twice. The difference between baseline and removal torque will be measured.
Results: RTVs were not significantly different between the groups. No screw fracture was seen.
Conclusion: Angulation of the abutments had no significant influence on the RTV.
Key Words: Abutment, Removal Torque Value, Screw Loosening, Dental Implant, Angle.

Abbreviations

CAD/CAM: Computer-Assisted Design and Computer-Assisted Manufacturing
FEA: Finite Element Analysis
RTV: Removal Torque Value

Introduction

Implant-supported restorations are a promising option for tooth replacement. Screws or cement can be used to secure implant-supported restorations, each with its own set of advantages and limitations (Misch et al., 2017). Screw retained implant restorations provide several advantages, including ease of restoration repair and a reduced risk of peri-implantitis caused by leftover cement. However, screw retention is not always achievable due to issues such as implant angulation misalignment, which results in an unsightly screw access.

There has been considerable discussion of the advantages and disadvantages of cement-retained implant-supported prostheses versus screw-retained implant-supported prostheses (Sherif et al., 2014). However, cement retention is frequently required for maxillary anterior implants with a labial angulation to avoid exposing the access. However, cement-retained restorations have been associated with an increased risk, which is mostly due to the failure to completely clear excess cement from the peri-implant area. Although the degree of difficulty in removing cement varies according to circumstances such as the placement of the subgingival margin or the crown undercut, some authors have deemed total eradication to be difficult, if not impossible. However, strategies have been developed to ensure that the peri-implant sulcus receives the least quantity of cement possible. Elimination is not the only obstacle; detection also presents a challenge, as radiography can show no more than 7.5 percent to 11.3 percent of cement in mesial or distal

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places (Wadhwani et al., 2009). As a result, clinicians may leave more residual cement in the sulcus than they think.

Nowadays, one of our goals is to fabricate screw retained abutment. It has many advantages over cement-retained abutment. Retrievability is the unique advantage of screw-retained abutment. Also, according to Wittneben et al., (2017) it has low involvement in peri-implantitis cases. The margin of porcelain could be extended deeper sub gingivally without concern of apical migration of soft tissue.

On the other hand, this type of abutment has disadvantages in the esthetic aspect. The bone of anterior part of maxilla has a thin bone plate which prevents us to use screw-retained abutment due to compromise the esthetics.

Cement-retained abutment is another type of abutment that can be used in implant cases. It's the best type esthetically with idealized occlusal contacts that will not be interfered with screw access channel. It has many disadvantages like lack of retrievability of the crown and the excess cement will cause initiation of inflammation to the soft tissue which may leads to peri-implantitis (Lee et al., 2010).

Recently, a new type of abutment is developed to enhance the quality of esthetic and function which called dynamic abutment (angulated abutment). It's suitable for all cases with high biocompatibility and to correct the path of insertion.it could be used in replacement of screw retained abutment with in cases need correction of angulation. We can see no excessive cement around the margin of the abutments of this type of abutment. It comes in different angulation from 10-28 degree.

Screw loosening occurs more in external hexagonal system under dynamic loading due to mechanical properties. Internal hexagonal system has modified biomechanical properties over external hexagonal by making changes in joint design. However, there was no significant impact on initial screw loosening among different types of abutments. However, Computer-Assisted Design and Computer-Assisted Manufacturing (CAD/CAM) abutment has that effect just after applying the dynamic load more than hundreds of times. The multi-unit abutment system shows lower percentage of RTV (removal torque value) after cyclic loading than single-screw abutment.

Research Problem

Dental implants have experienced numerous modifications and advancements. Despite this, numerous difficulties such as osseointegration failure, soft and hard tissue abnormalities, and biomechanical issues have been reported on a continual basis. Abutment screw loosening is the most prevalent mechanical problem associated with implant-supported restorations. Abutment screw loosening was identified as the most often observed issue in various clinical assessments of implant-retained prostheses. Despite extensive clinical and in vitro research, the exact cause of abutment screw loosening remains unknown. Other investigations indicated that implant-abutment assemblies were stable, with just a few instances of abutment screw loosening. Additionally, some in vitro investigations observed a decrease in removal torque values (RTVs) during cyclic loading, while others reported no significant decrease.

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Screw loosening results in an unstable implant-abutment connection and the establishment of a micro-gap, which might result in implant component fracture. The space may allow bacteria to infiltrate, which is detrimental to the surrounding tissues. Additionally, implant screw loosening or failure may result in component failure, necessitating more comprehensive repair. Screw loosening is influenced by a number of factors, including tightening force, design, and screw material. Preloading the screw joint is critical to avoiding screw loosening. If the preload is reduced below a critical value, joint stability may be compromised, compromising the screw joint's stability.

Abutment screw loosening is the most frequently encountered mechanical issue with screw retained restorations and bespoke abutments. An average of 6% screw loosening has been documented in implant restorations. A loose abutment screw can result in biological or mechanical issues such as bacteria colonizing the abutment-implant junction, crestal bone loss, and screw, abutment, or implant body fracture. External pressures such as parafunctional habits, arch position, cantilevers, occlusal designs, implant locations, non-passive sitting, and insufficient or excessive screw torque can all increase the risk of screw loosening. When torque is applied to an abutment screw, it elongates the screw, creating a tensile force between the shank and screw threads termed the preload. When an appropriate preload is obtained, the screw's elastic recovery generates the clamping force necessary to secure the restoration or abutment to the implant. Each implant system has a unique torque recommendation for each abutment screw, which should be followed. When torque is reduced below the manufacturer's suggested value, insufficient clamping force results, which might result in screw loosening. On the other hand, excessive torque can cause screws to bend, resulting in a loss of clamping force.

Objective

The purpose of this in-vitro study was to evaluate and compare the removal torque values of dynamic abutment and multi-unit abutment. Specifically, 17-degrees angulated abutment and straight abutment of each type.

Importance of the study

A series of good findings on the clinical success and efficacy of osteointegration with implant therapy has elevated it to a popular method of tooth replacement. Historically, osseointegrated dental implants were largely utilized to rehabilitate patients who were fully edentulous, via implant-supported bridges and implant-retained complete dentures. Later, depending on the clinician's skills, dental implants were used for single tooth replacement, maxillofacial prosthetics, and other uses. The focus of implant dentistry research has shifted away from mastering surgical techniques and grafting procedures and toward addressing the mechanical and aesthetic concerns that have been identified as the primary causes of implant failure or complications, as well as unsatisfactory treatment outcomes.

Today’s patients anticipate lifespan, function, and aesthetics from their implant-supported restorations. The cosmetic outcome of an implant-supported restoration is based on the soft tissue contour and affected by the right location of the implant. However, the presenting anatomy of the anterior maxilla generally does not allow for an implant angulation that will allow a screw-retained repair without the need of extra components. Often the treatment for this sort of implant angulation is to create an abutment intended to receive a cemented restoration. Cemented restorations have disadvantages compared with screw-retained restorations, including the effects of excess cement and lack of retrievability.

Expressions

Abutment: A dental abutment is used to link two or more restorative dentistry parts. When referring to a dental bridge, the abutment teeth are the two adjacent teeth that serve as the bridge's anchors or the teeth that serve as the anchors for a partial denture. When dental implants are used in conjunction with a dental restoration, abutments are utilised to secure the bridge or other tooth replacement to the fixture implanted in the jawbone.

Removal Torque Value: The rotational force required to remove or unscrew a threaded closure from a bottle finish. It specifies the rotational force required to dislodge, open, or remove the closure.

Screw Loosening: When the joint-separating forces acting on the screw joint are larger than the clamping forces holding the screw unit together, screw loosening occurs. Tightening results in a small flattening of the micro roughness of the entire metal contacting surface, reducing the distance between the contacting surfaces.

Dental Implant: A dental implant is a metal post that replaces the missing tooth's root section. An artificial tooth (crown) is attached to an extension of the dental implant's post (abutment), giving the appearance of a natural tooth.

Theoretical Framework

Teeth may be lost for a variety of causes. They may be lost as a result of tooth decay, periodontal disease, or trauma. They may be present at birth as a result of genetic, epigenetic, or environmental causes, or as a result of specific syndromes. Dental implant-supported restorations can be used in place of conventional removable dentures to restore function and aesthetics. Additionally, dental implants can be utilised to stabilize fixed partial dentures and single crown restorations (Walton et al., 2017).

The high success rate of dental implant treatment is a result of the osseointegration process, which involves direct contact between an implant and living bone, as visible under a light microscope. Despite the great success and survival rates documented in several research and reviews, dental implant procedures can nevertheless result in problems. Complications might be biological, mechanical, or aesthetic in nature (Ma et al., 2015).

Dental implants – techniques of restoration

Retention of an implant-supported restoration can be accomplished in two ways: screw retention or cement retention. Numerous authors advocated for screw retention because it enables the retrieval of an implant-supported restoration in the event of a problem. To optimize the aesthetic outcome of the prosthesis, the screw access hole should be located on the palatal area of front teeth or on the occlusal area of posterior teeth (Sailer et al., 2012).

Correct three-dimensional location of a dental implant is critical for reducing aesthetic issues. Failure to follow precise treatment planning procedures may result in the implant being oriented incorrectly labio-lingually, resulting in a labial screw access hole, an unacceptable aesthetic compromise.

Several techniques exist to fix mispositioned dental implants: cementing the restoration, using angled abutments, cross pinning, and utilizing angled screw channel abutments.

Cement retention

To avoid circumstances when the dental implant's position results in an unsightly screw access hole, many practitioners favor cement retention. Cement-retained prostheses are more affordable and straightforward to build than screw-retained prostheses. A cemented implant-supported restoration is similar to a conventional fixed restoration that is cemented onto natural teeth, and so is constructed using conventional clinical and laboratory technical stages.

Retrieving a cement-retained restoration is a risky process in the event of difficulties. Due to the film thickness of the cement, a gap between the abutment and the implant-supported crown will always exist. Due to this cement line, cement-retained prostheses have a larger marginal misfit than screw-retained prostheses (Vindašiūtė-Narbutė, 2018).

Excess cement is difficult to entirely remove and can contribute to the development of peri-implantitis. Subgingival cement residue can potentially result in peri-implant mucositis (Levin, 2020). Having deeper subgingival abutment margins increases the likelihood of undetected leftover cement being a problem. Radiography is ineffective at detecting interproximal cement excess.

Extreme caution must be exercised when cemented implant crowns are used, particularly in patients with high cosmetic expectations. As a result, the option to permanently cement an implant-supported restoration must be carefully examined.

Screw retention

In comparison to cement-retained restorations, screw-retained restorations can be predictably recovered in the event of mechanical failure or biological complication. A screw-retained implant-supported crown/abutment complex can be directly linked to the implant through an abutment screw, achieving direct-to-fixture retention (Wittneben et al., 2017). Due to the fact that these restorations require more complicated laboratory processes than cement-retained restorations, their cost is higher. This must be considered against the prospective expenses of reversing the restoration once it has been cemented. The most frequent technical issue associated with single crown restorations on dental implants is abutment screw loosening. Another potential technical difficulty associated with screw-retained implant-supported restorations is screw head stripping. This may occur as a result of repeated tightening and loosening of the screw, resulting in screw head wear and physical changes. Incomplete seating of the screwdriver and excessive torque may potentially result in head stripping. To minimize the possibility of screw head stripping, the screwdriver must be fully seated in the screw head and the appropriate torque amount applied.

Angled abutments

When the remaining ridge anatomy is weak and bone grafting is contraindicated or not considered, it may be impossible to place the implant in the optimal axial prosthetic position. In such cases, it was proposed to put the implant at an angle and to use an angled abutment. According to studies (Cavallaro Jr et al., 2011; Tian et al., 2012), utilizing angled abutments places an excessive amount of stress on the implant and its surrounding bone. According to a recent systematic review and meta-analysis, using angled abutments results in increased marginal bone loss and implant failure.

Cross-pinning

By utilizing a lingual or palatal transverse screw to secure the restoration to a screw-retained abutment, prosthetic retrievability is provided in the event of an unfavorable dental implant alignment. The manufacturing of a cross-pinned implant-supported restoration is more technically demanding, resulting in a higher production cost (Wang et al., 2016).

Angled screw channel abutments

When direct-to-fixture screw retention is deemed impractical for cosmetic reasons, they are utilized to allow direct access to the abutment screw by deviating the angle of the screw channel within the restoration (GÜRPINAR et al., 2020), hence offering a direct-to-fixture option for tilted implants. Due to the hex lobular shape of the screwdriver and the accompanying abutment screw, angle adjustment is feasible.

Comparison of cement and screws as retainers for prostheses

Clinical trials have confirmed both cement- and screw-retained prostheses, and each technique of retention has distinct advantages and limitations (Table 1). Historically, screw-retained prostheses were frequently used on dental implants due to their ability to be removed for examination of the underlying implants and treatment of any issues. Cemented restorations are currently extensively employed because they enable the creation of a more beautiful restoration. While they are not as retrievable as screw-retained prostheses, provisional cementing allows for some retrievability. There is some indication that cement-retained fixed prostheses are associated with less post-delivery prosthodontic problems (Vigolo et al., 2012).

	Cement-retained	Screw-retained
Retrievable	not easily	yes
Aesthetics	excellent	variable
Correction of misaligned implant	usually	sometimes
Ease of insertion	conventional techniques	difficult in posterior areas
Retention at minimal occlusal height	marginal	excellent
Passive fit	yes	questionable
Maintenance	minimal	moderate

Table (1): Features of cemented and screw-retained restorations

Implant-abutment interface

The geometry of the implant-abutment contact is responsible for joint strength and stability, as well as for location and rotational stability, for both screw and cement retention techniques. External hexagonal connections were commonly employed in the past. Instead, then giving physicians an anti-rotational feature (Gracis et al., 2012), it was designed to help with implant implantation. Off-axis loading and substantial functional and parafunctional loads can limit the efficacy of an exterior hexagonal design, which has a very small height.

Joint opening and screw loosening can result from various forces acting on the screws used to hold them in place. The short engagement and short fulcrum when tipping forces are applied make this problem typical with short narrow external connections (Krishnan et al., 2014). Controlled torque applications, revised screw designs, hex height and breadth alterations, and hex design modifications such as taper and

corner engagement recesses and micro-stops can all help solve this issue.

The internal connection was devised to increase predictability and to prevent or minimize the mechanical problems associated with the exterior hexagonal connection. It was believed that this method would alleviate stress on the crestal bone, although this has been questioned by other experts. Internal connections are available in a variety of configurations, including cone screw, cone hex, internal octagonal, hexagonal, and cylindrical hex, Morse taper, spline, internal spline, and robust (Shafie, 2014).

Angulation of the implant and abutment selection

Implants put at an unfavorable position or angle can be difficult to repair and can result in unfavorable and unsightly consequences. The implant's precise angulation can be determined using the fixture level impression. This angulation then guides the choosing of abutments.

Angulation of the Implant

The implant's position dictates how it will interact with the ultimate prosthesis, neighboring teeth, and the opposing arch. If the implant does not conform to the correct mesio-distal, faciol-ingual, or apico-coronal parameters, it may be deemed unrestorable, or if it is used, the prosthesis may be compromised due to issues with undesirable biological contours, screw channel emergence, and non-axial loading on the implant system (Turkoglu et al., 2019). An implant that is not in the correct tooth position is more difficult and expensive to restore. It introduces prosthetic and aesthetic issues and significantly complicates the procedure of abutment choosing.

Selection of Abutment

The primary disadvantage of cement retained restorations was their retrievability and the difficulty of removing excess cement, which resulted in local inflammatory reactions such as peri-implant mucositis and peri-implantitis ("peri-cementitis"). Cement residues are particularly difficult to detect in restorations with deep subgingival margins, and radiographs are ineffective at detecting excess cement, as many cements are not highly radiopaque (Wadhwani et al., 2015). Screw retained restorations provide reliable retrievability and are preferred when a screw emergence profile is desired, i.e., not through the facial, buccal, or occlusal surfaces. When the screw access is positioned in the aesthetic zone and is plainly visible to unassisted direct vision, it detracts from the case's overall aesthetics.

Numerous solutions available for resolving implant angulation issues. If the angulation is less than 15 degrees, prefabricated abutments may be used; however, angulations more than 15 degrees are most frequently rectified prosthetically using angle corrected prefabricated abutments, angulated, cementable, or custom abutments. This angulation issue is especially critical with screw-retained restorations where the screw channel is located on the face aspect (Karunagaran et al., 2013).

Angle corrected prefabricated implant components may be utilised to fix implant angulations ranging from 15 to 20 degrees. A mismatch in angulation of more than 20 degrees may necessitate the use of bespoke abutments. A cementable angulated abutment can be used to correct angulation mismatches of 15-25 degrees, while a screw-retained angular abutment can correct mismatches of 17, 25, 30, and 35 degrees.

While the use of angulated abutments is well documented, it is a contentious matter, as it results in strains and pressures along the implant-bone interface. Despite this, some research indicates that angulated abutments do not harm the supporting bone. Berroeta et al., (2015) conducted a finite element analysis (FEA) and discovered that angled abutments resulted in greater implant and cortical bone stress and strain than straight abutments. Another study conducted by Kao et al., (2008) demonstrated that when abutments with a 25° angulation were employed, micromotion increased by 30% and peri-implant bone stresses increased by 18%. The distribution of stress is controlled by a variety of additional biomechanical parameters, including the kind of load, the implant and prosthesis material qualities, implant geometry, the implant-bone contact, and the quantity and quality of surrounding bone. In terms of clinical use and lifespan, one study (Cavallaro Jr et al., 2011) found a 98.6 percent survival rate during a 5-year period, and the same group later reported a 98.2 percent survival rate at 14 years. Another study (Wu et al., 2010) discovered no difference in performance between regular and angled abutments.

Abutment screws and screwdrivers

Dental implant systems are composed primarily of many primary components, starting with a surgically inserted endosteal component that is connected to an abutment to support the restoration. The abutment screw is used to secure the abutment to the implant, forming the implant-abutment complex. Physiological forces have an effect on the restoration and the implant abutment connection during function.

Abutment screws

The screw is a straightforward machine that operates on the same principle as a spiral inclined plane. It is composed of two components: a screw head and a screw shaft. A screw's function is to secure the implant-abutment assembly against the attack of joint separation forces while also being retrievable for serviceability. Screws are primarily used in implant restorations to secure the various prosthetic components to the implant body (i.e., the abutment for screw retention, the abutment for cement retention, or the abutment for attachment) (Misch, 2015).

The abutment screw was invented with the goal of increasing preload and minimizing torque loss due to friction. A standard screw is composed of a head and a long stem with six thread lengths. The head serves as a point of contact for the screwdriver, which is turned along its long axis using a torque wrench to apply the necessary torque to the screw, which creates tension in the stem length and causes it to elongate. A lower thread length contributes to friction reduction.

Screwdrivers

Screws are torqued or tightened in implant dentistry using a manual torque wrench or a digital torque wrench. For an abutment or prosthetic screw, the majority of manufacturers recommend delivering a torque load of approximately 20-30 Ncm. Torque at this magnitude has no detrimental effect on the bone-implant interface. The likelihood of a screw loosening and the amount of torque applied by a torque wrench vary and are somewhat dependent on the operator's strength. The typical torque delivered by a simple hand screw driver is roughly 10 Ncm, whereas a torque driver is required to deliver more than 20 Ncm. Torque values greater than 30-35 Ncm are harmful to the implant-bone interface. Standardization of the torque driver is necessary to ensure consistent performance each time it is utilised. Using a torque wrench significantly reduces the likelihood of a screw loosening. The use of a hand screwdriver is restricted to the installation and removal of non-critical components such as healing abutments or impression copings (Alikhasi et al., 2017).

The metal composition of torque wrench screwdrivers has an effect on their performance. Torque wrench screwdrivers are typically made of titanium alloys. In comparison, screw heads can be produced of gold and titanium alloys. This aim is to engage the screw head precisely and without distorting it, while also using a tougher material for the driver to ensure its longevity. Similarly, some drivers may have their surfaces coated with an incredibly hard substance such as titanium nitride, making them significantly more durable than the screws.

A well-known issue is that a screwdriver can cause the screw head to peel. If this occurs, it creates significant difficulties while tightening or removing the screw. Stripping occurs as a result of metal friction between the driver head and the screw head, and is much more likely to occur when excessive force is applied to the screw head, the driver is not correctly engaged in the screw head, or the improper driver is used. Because the screw head is softer than the driver head, the metal-on-metal frictional wear deteriorates it (Lee et al., 2021).

Morphology of screws

The newest designs of implant abutments are intended to minimize torque input loss and maximize preload, with the screw serving as the weakest link in the implant-abutment interface assembly. As previously stated, a screw's usual design consists of a head and a long stem with six thread lengths (Misch, 2014). A longer stem length assists in attaining the ideal length, while a lower thread length reduces friction. This minimizes torque loss due to friction and enables a larger preload.

The most frequently utilised thread design is the V-shaped 30-degree angle, as this configuration concentrates tension on the screw's initial few threads. Typically, manufacturers employ a limited number of threads on their abutment and prosthesis screws. A flat head screw with 4-5 threads is the most often used prosthetic screw.

The spiralock thread design, which had eight to ten threads, exhibited no screw loosening. The spiralock design was developed expressly for the aircraft industry to address the issue of screws loosening under adverse conditions such as high pressure, strong vibration, and intense loading. This screw design distributes tension evenly across all treads and has more threads than screws with standard V-shaped threads (Olate et al., 2010).

Tapered head screws are no longer utilised since their head-to-shaft load ratio was 4:1, but flat head screws had a head-to-shaft load ratio of 1:1. The head of a screw with a flat head distributes forces equally, but the head of a screw with a tapered head distributes forces to the head rather than into the fixation screw, resulting in less-than-ideal torque and a reduced clamping effect from tensile force. In comparison to a flat head, a tapered head distorts and aligns a non-passive framework and casting, creating the illusion of good fit.

Mechanics of Screw

A fundamental grasp of screw mechanics is required to offer patients with implant-supported screw-retained restorations of the highest quality. The physician must be conversant with the screw releasing mechanism in order to keep the screw securely attached. The primary purpose of a screw is to generate and sustain a compressive force between joint elements - the clamping force, which is described as "the compressive force exerted by a fastener on a bolted joint." Tension builds within the screw as joint parts compress against one another. The phrase "preload" refers to this tensile force. Due to the fact that the longevity of a screw joint is dependent on the clamping force's stability, an extremely strong clamping force should be

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established to withstand forces working to separate the joint. Take care not to exceed the upper limit specified by the screw material's yield strengths.

It is critical to grasp the foundations of screw mechanics in order to accurately forecast how a screw will behave under various conditions. While the ease with which a screw-retained prosthesis can be unscrewed and recovered is an advantage, it is equally important that the screw connections remain secure when functionally loaded. As previously stated, screws are the implant assembly's weakest link. Any occlusion defects, faults in the fitting of the casting frameworks and abutments, and off-centric forces may create vibrations during operation, resulting in the screw loosening or breaking.

The screw joint is made up of two components that are secured together by the screw. To keep the joint intact and the two components together, the external forces attempting to separate the joint must be less than the forces holding the two components together. In other words, these separation forces, also known as 'joint separating forces,' must remain below the 'clamping forces' that hold the components together (Jörn et al., 2014).

Tightening the screw generates the initial clamping pressures. This creates tension in the screw, and the resulting compressive forces hold the screw joint together. Screw elongation occurs as a result of the tightening or torque imparted to the screw. Preload is proportional to the frictional forces between the mating threads and the screw head, the screw's metallurgical qualities, and the closing torque applied.

Screw loosening is mostly caused by embedded relaxation. When torque is given to the new screw and bolt combination, some of the energy is used to smooth the mating surfaces, with the remainder directed toward screw elongation. The thread surfaces or asperities are flattened at the contact point, thereby reducing the screw's elongation. This now takes additional torque to compensate for the screw's elongation and preload. The initial friction is more than that necessary for future screw tightening. Repeated tightening and loosening cycles diminish friction, which makes the screw more prone to loosening when subjected to functional loading.

To apply preload to the abutment screw, a torque of 50%–75% of the amount that induces permanent deformation is advised. This tensions the screw and creates over clamping forces between the implant system's components, preventing the screw from loosening. Following that, the screw experiences a settling effect, also known as embedded relaxation, in which the screw gradually recoils, resulting in small loosening, because the torque exerted was less than the torque required to cause permanent deformation (Jo et al., 2014).

Due to the settling effect, the torque required to remove the screw is always less than the torque necessary to tighten it. When studied under very high magnification, surfaces that appear smooth to the human eye or low magnification are actually rough, and this roughness is a byproduct of the fabrication procedures employed in screw production.

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When two seemingly flat surfaces come into touch, they do so at a succession of points. Typically, these protrusions are wedge-shaped rough formations. When the screw is initially torqued, these projecting surfaces level out under load. This flattening brings the two surfaces closer together, and around 2-10% of the preload is lost as a result of settling. Additional torque is necessary to re-tighten the screw to 75% of its yield strength 10 minutes after initial tightening in order to achieve screw elongation and generate preload.

While friction between mating parts is greatest during the initial insertion cycle, it diminishes with subsequent insertion cycles, i.e., repeated tightening and loosening cycles. When the total settling action of the mated pieces exceeds the friction between them, the screw becomes loose. Loss of retention owing to abutment screw loosening is one of the most often seen issues with screw-retained restorations, and is particularly problematic with single-implant supported restorations with an external connection. In theory, increasing the preload should increase joint stability and alleviate the issue of loosening.

Inadequate clamping force, screw settling, biomechanical overload, off-centric forces on the implant, misfit of implant components, changes in screw characteristics (screw diameter, screw material composition, screw head design, screw thread design), implant diameter, and abutment engagement method can all contribute to screw loosening (e.g., external hex, internal hex, and the hex height) (Shadid et al., 2012).

Material for screws

From a purely mechanical standpoint, the screw's metallurgical composition has an effect on its performance. When loaded under similar conditions, the yield strengths of screws differ according to their composition. For instance, a gold screw has a yield strength of only 12.4 N, whereas a titanium alloy screw has a yield strength of 83.4 N. Due to this compositional mismatch, a prosthetic screw may fracture when subjected to torque loadings ranging from 16 to 40 Ncm, depending on the material utilized.

In general, the screw material composition will dictate the strain in the screw due to preload, as well as the point at which the screw fractures or reaches its breaking point. Titanium alloys have a greater resistance to bending fracture than grade 1 titanium and are 2.4 times as strong as grade 4 titanium (Niinomi et al., 2015). Thus, greater torque values are possible when titanium alloys are employed; this is true for screws as well as a variety of other implant components.

Screws have evolved significantly over the last two decades. When utilised in conjunction with a titanium implant, a titanium screw causes frictional resistance between the screw thread and the implant thread. This results in a type of adhesive wear as a result of sliding contact between similar materials. This wear is referred to as 'galling' and is what causes titanium screws to lose their preload properties. This issue resulted in the development of gold alloy screws. These materials offer a lower friction coefficient and a better yield strength. They can create twice the amount of preload at 75% of their yield strength as titanium screws.

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The primary disadvantage of utilizing gold screws is that their threads are prone to distortion. As a result, their application must be restricted to the final clinical placement procedure. To address these difficulties connected with gold screws, coated implantation screws such as Torq-Tite and Gold-Tite have been introduced. Teflon coating was applied to the Torq-Tite screw, which reduced the coefficient of friction by 60% and increased the preload. Gold-Tite uses pure gold to cover the gold alloy screw, which is a softer substance than the alloy. This strategy was relatively pricey, but resulted in a 24 percent increase in preload (Park et al., 2010). Only a few long-term clinical experiments have been conducted to determine the effect of frequent opening and closing on coated screws.

Torque and preload concepts

Torque is the force acting on an object to cause it to rotate. Frequently, screws are tightened by applying torque to their heads, creating screw tension or preload. Due to the fact that pure metals and alloys are somewhat elastic, and the screw can act as a spring, preload develops as the screw elongates (Bulaqi et al., 2019).

The clamping force that results is directly proportional to the torque employed to tighten the joint. Because torque is very easy to measure with a torque wrench, it is frequently employed in error as a preload indicator. Almost 90% of the initial kinetic energy is wasted as a result of friction between the screw and joint parts and a phenomenon known as nut dilatation. Due to the near-impossibility of predicting how much input torque will be lost, more torque is desired because it generates more preload. This is due to the linear relationship between the torque given to a screw and the produced preload within it, which is defined as torque = preload * constant. Preload boosts the strength of the screw joint by keeping it tight (Zhou et al., 2016). Additionally, it provides friction between joint parts to prevent shear and increases the joint connection's fatigue resistance.

Torque, on the other hand, cannot be applied arbitrarily. The torque that may be exerted is limited by the screw's mechanical strength. The absolute maximum torque is theoretically reached immediately before screw fracture occurs. As a result, a safety buffer should be developed to reduce the danger of screw fracture while maintaining an acceptable preload.

Implant dentistry screw loosening causes

Screw loosening is caused by a decrease in clamping force in a variety of ways. "Embedment relaxation, elastic interactions, creep of metal components, gasket influence, external tensile stresses, hole interference, resistance of joint elements to being brought together, prevailing torque and differential thermal expansion" are some of these mechanisms.

The procedure for releasing dental implants screws can be simplified by dividing it into two steps. Initially, after the joint has been subjected to a variety of external forces, the preload decreases as a result of the frictional forces that maintain the screw extended being disrupted. At this stage, a higher preload reduces the likelihood of loosening. If further force is applied and the preload decreases to a critical value, the screw joint will fail due to forces causing it to "back off"(Cicciù et al., 2018).

Embedment relaxation occurs shortly after a screw is originally torqued. Due to the fact that no thread surface is perfectly flat at the microscopic level, even when highly polished, only the projecting points come into contact with the screw channel and are stressed. As these points flatten, a 2-10% drop in preload occurs. When those "settling effects" exceed the screw's elastic elongation, the assembly will loosen due to the absence of contact forces to hold it together. Retightening the screw after 15 minutes is recommended to resolve this issue (Arshad et al., 2018).

Loosening can also occur as a result of excessive screw joint bending. When the screw's yield strength is exceeded, the screw undergoes permanent plastic deformation, the preload is lost, and the screw joint becomes loose. This can exacerbate the settling effect's issues. Before the final restoration is inserted, abutments may be placed on and removed from an implant many times.

Previous Studies

According to Al-Otaibi et al., (2017): The Effect of Torque Application Technique on Screw Preload of Implant-Supported Prostheses

To determine the effect of various torque application strategies on the removal torque of implant-supported fixed full dental prostheses (torqued, retorqued once, and retorqued twice). Four Nobel BioCare implants (4.3 13 + 3; thread height 13 mm + collar height 3 mm) were temporarily stabilized inside four holes drilled in an acrylic mandibular master model. A systematic technique was used to create, cast, and finish a metal framework. By extracting the implants from the acrylic master model and hand-screwing them to the metal framework, a passively fitting framework was obtained. The assembly was then reassembled in the acrylic master model. Three protocols were used in the torque experiment: (1) torquing screws to 35 Ncm once; (2) torquing screws to 35 Ncm and immediately retorquing them to the same value; and (3) torquing the same screws to 35 Ncm three consecutive times. A digital torque meter was used to record the removal torque for each implant. The retorqued-once application strategy produced the greatest torque value (29.5 ±1.5 Ncm); the torqued technique produced the second highest torque value (27.9± 0.7 Ncm); and the retorqued-twice application technique produced the third highest torque value (27.2 ±1.6 Ncm). The Games-Howell post hoc test revealed that the retorqued-once application strategy produced considerably greater torque values than the torqued and retorqued-twice application techniques ($P \leq .05$). Retightening abutment screws once after first torquing may increase the screw's removal torque. Caution must be exercised while retorquing the screws multiple times, as this may have an adverse effect on the removal torque.

The study of Kim et al., (2020): Axial displacements and removal torque changes of five different implant-abutment connections under static vertical loading

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The purpose of this study was to determine how abutments settle into implants and the value of the removal torque under static stress. Five distinct implant-abutment connections were chosen: Ext: external butt joint + two-piece abutment; Int-H2: internal hexagon + two-piece abutment; Int-H1: internal hexagon + one-piece abutment; Int-O2: internal octagon + two-piece abutment; Int-O1: internal octagon + one-piece abutment. Ten implant-abutment assemblies were loaded vertically downward in a universal testing machine using a 700 N load cell at a displacement rate of 1 mm/min. The abutment's settling was determined using an electronic digital micrometer by comparing the total length of the implant-abutment unit before and after loading. With a digital torque gauge, the post-loading removal torque was compared to the original torque value. After 700 N static loading, the settling values and removal torque values were as follows: Ext < Int-H1, Int-H2< Int-O2< Int-O1 and Int-O2 Int-H2, <Ext Int-H1, Int-O1 (α= 0.05). After 700 N vertical static loading, the removal torque values were statistically different from the initial values, increasing in the Int-O1 and Int-H1 groups (α= 0.05), while decreasing in the Ext, Int-H2, and Int-O2 groups (α= 0.05). According to the findings of this investigation, a loss of preload due to the settling effect can result in screw loosening during a clinical operation in the molar area, where masticatory force is significantly stronger.

According to Al-Otaibi et al., (2018): Effect of different maintenance time of torque application on detorque values of abutment screws in full-arch implant-supported fixed prostheses

The effect of varying the torque application and screw loosening times in a full-arch implant-supported prosthesis is unknown. The goal of this study is to determine the influence of various torque maintenance times on the detorque values of implant abutment screws in a full-arch implant-supported fixed complete denture. Passively fitting framework supported by four implants torqued to 35 N-cm and sustained for varying times; instant torque application (protocol A), ten seconds torque application (protocol B), and thirty seconds torque application (protocol C) were utilized. During the screw removal process, detorque data were recorded. A paired sample t-test was used to compare the mean torque and detorque values. Three-way analysis of variance was used to compare the mean removal torque values for each protocol (ANOVA). For all treatments, the mean removal torque was less than the applied torque. The immediate protocol (A) had the highest mean removal torque (24.44 ±1.7), followed by the 30 seconds protocol (C) (23.37 ±1.75), and finally the 10 seconds protocol (B) (23.35 ±1.6). All of these variations between torque and detorque values were determined to be statistically significant (P =.001). The differences in detorque values, on the other hand, were not statistically significant (P >.05). The application of 35 N-cm torque to an implant abutment screw for a variable duration of time did not appear to impact the detorque value in a multiple implant-supported fixed prosthesis. Maintaining torque for a lengthy period of time (10 or 30 seconds) had no statistically significant effect on preload in full-arch implant-supported prostheses.

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The study of Lee et al., (2018): Screw loosening and changes in removal torque relative to abutment screw length in a dental implant with external abutment connection after oblique cyclic loading

The influence of abutment screw lengths on screw loosening and removal torque in external connection implants under oblique cyclic stress was examined in this study. External connection implants were fastened to straight abutments using abutment screws. Seven groups of abutment-implant assemblies were created based on the length of the abutment screw, with each group consisting of five assemblies. Until one million cycles were achieved, a cyclic load of 300 N was applied at a 30o angle to the loading axis. The removal torque values (RTVs) were determined before and after loading, as well as the discrepancies in the RTVs. Repeated measures analysis of variance with Student-Newman-Keuls multiple comparisons was used to analyze the measured values. Without screw loosening, all assemblies passed the oblique cyclic loads test. When the abutment implant assemblies were loaded repeatedly, the RTVs decreased significantly over the measured abutment screw lengths (P<.001). However, when the abutment screw length was between 1.4 and 3.8 mm (P=.647), there was no significant variation in the abutment screw length on the RTVs before and after the experiment. Within the constraints of this experiment, our findings suggest that when a minimum length of 1.4 mm (3.5 threads) was engaged, the abutment screw length had no significant effect on the RTV differences after oblique cyclic loading. These data imply that short abutment screws may provide equal load resistance to lengthy screws.

According to Berroeta et al., (2015): Dynamic abutment: a method of redirecting screw access for implant-supported restorations: technical details and a clinical report

The implant position has an effect on the aesthetic outcome of implant-supported restorations. A well-placed implant will enable the restoration to be contoured appropriately, and when combined with an adequate volume of soft tissue, will result in a functional and cosmetic repair. When a screw-retained repair is envisaged, an implant that is tilted too far forward on the facial ridge would be unsatisfactory aesthetically. The Dynamic Abutment (Talladium International Implantology) became commercially accessible in 2004. This abutment allows for a deviation of up to 28 degrees between the restoration screw access angle and the implant angle, while nevertheless connecting a screw-retained restoration directly to the implant platform. This article was written to describe the components, technique, and clinical application of this abutment.

Method and Materials

Eight specimens were created by embedding titanium internal hexagon implants (Osseotite; Zimmer Biomet) in self-polymerizing methyl methacrylate (Technovit 4000; Kulzer) using a custom-designed positioning mechanism.

These specimens were divided into 4 groups: control group 0GS (0 degrees and Gold square screw; UNISG; Zimmer Biomet); group 0DAS (0-degree and DAS); group 17DAS (17-degree and DAS); and group 17AS (17degree and AS) as test groups.

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All specimens were castable DA for a 4.1-mm internal hexagon implant. The DA was positioned at 0 degrees angulation in groups 0 GD and 0 DAS; at 20 degrees angulation in group 17DAS; and at 28 degrees angulation in group 17AS (figure 1). All angulations were determined relative to the implant's long axis and confirmed by two investigators using a parallel meter and a protractor.

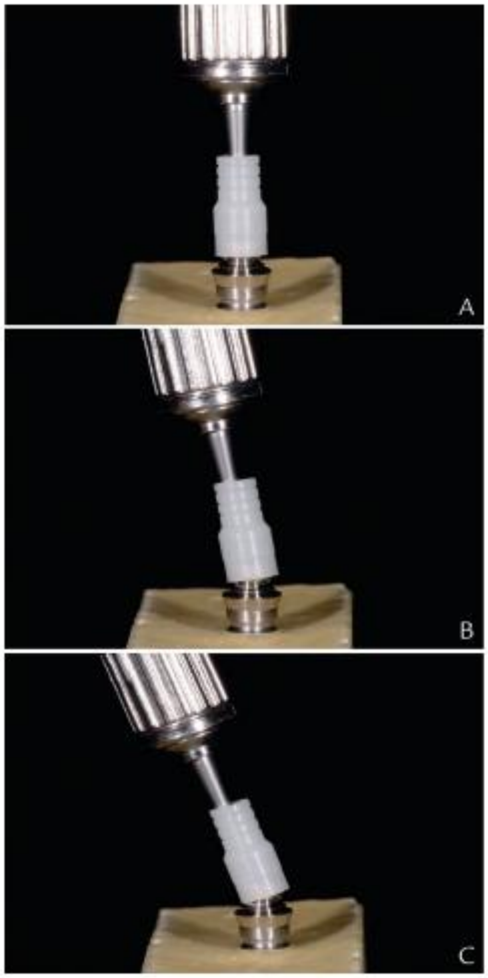

Figure 1: Model with castable dynamic abutment. A, 0-degree angulation.

B, 17-degree angulation

Each abutment was molded to the anatomic contour of a left maxillary incisor crown (figure 2) and cast in a Ni-Cr alloy (Tilite; Talladium Intl) using an automated casting process (KDF; Neo Super Cascom) (figure 3). After devesting and polishing the abutments, a small indentation was created on the mesiolingual area with a #4 round tungsten carbide bur (Brasseler USA) to produce a point for consistent loading.

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Figure 2: Model with anatomic contour waxing on dynamic abutment

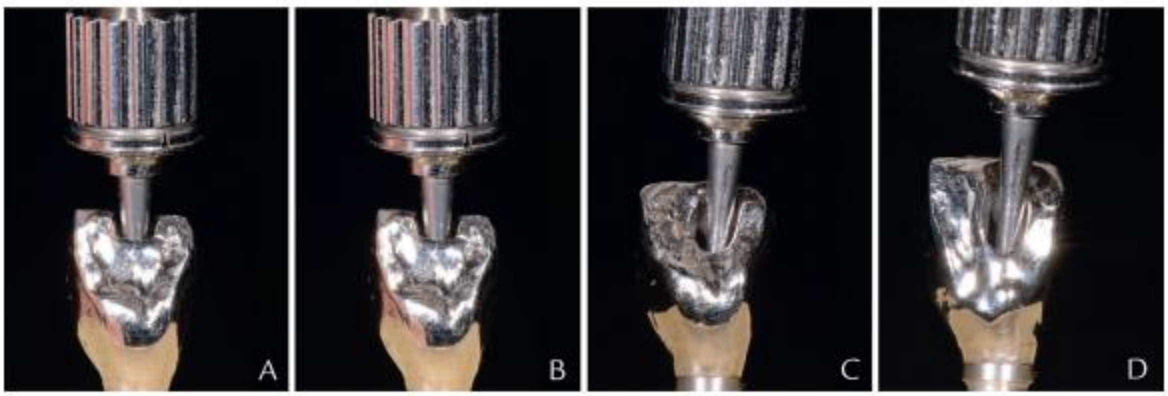

Figure 3: Cast specimens. A, 0-degree gold screw. C, 17-degree gold screw

After fabricating all specimens, we screwed the restorations onto the implants to create a baseline for the RTV. We inserted and removed each screw three times, measuring the torque and removal torque values using a universal torque wrench.

Recently, a titanium abutment screw (dynamic abutment screw) was introduced that may be tightened non-axially. Nonaxial tightening is enabled by the hex lobular screw driver and associated abutment (dynamic abutment), which enables the placement and fastening of a screw-retained restoration to an implant while allowing for a nonaxial screw channel. This method avoids the need for an intermediate abutment, additional restorative space, or mucosal thickness to conceal the implant components.

Although a clinical report was just published, a search of published research revealed no data on this angulated abutment and screw system. As such, the goal of this study was to investigate and compare the effects of RTV and force to failure on implant-supported restorations that are cyclically loaded.

The hypotheses examined were that the gold square screw would have a higher RTV and would be more resistant to fracture than the DAS at 17 degrees, and that the DAS at 0 degrees would be statistically equivalent to the DAS at 17 degrees. The final screw RTVs were determined using the universal torque wrench in the same manner as the baseline values.

The FS of each specimen was determined using a universal mechanical testing equipment. The implants were held at a 30-degree angle using a rigid clamp system while the specimens were loaded under compression at a crosshead speed of 1 mm/min until failure or evident deformation occurred. The peak loads were measured in newtons, and the testing technique followed ISO guidelines (ISO 14801).

Sample	Initial Torque	Force applied	N. Of cyclic loading	Frequency	Reverse Torque	Screw open after Reverse Torque
M1(straight)	15	40 newtons	600,000 cycles	2 cycle per second	10	No
M2 (straight)	15	40 newtons	600,000 cycles	2 cycle per second	10	No
M3 (angled)	15	40 newtons	600,000 cycles	2 cycle per second	10	No
M4 (angled)	15	40 newtons	600,000 cycles	2 cycle per second	10	No
D1	25	40 newtons	600,000 cycles	2 cycle per second	20	No
D2	25	40 newtons	600,000 cycles	2 cycle per second	20	No
D3	25	40 newtons	600,000 cycles	2 cycle per second	20	No
D4	25	40 newtons	600,000 cycles	2 cycle per second	20	No

Table 2: The sample

Through entering all data into a spreadsheet and determined the mean baseline and final RTVs. We calculated the difference between baseline and removal torque (DRT) values and compared the DAS at various angulations to the typical gold square screw. The statistical analysis was conducted using a one-way ANOVA for DRT (a=.05), which was performed using statistical software (IBM SPSS Statistics v19; IBM Corp). We checked the normality and homoscedasticity of the data prior to doing the 1-way ANOVAs (Kolmogorov-Smirnov test, P>.05; Levene test, P>.05).

Results

	Group 0GS	Group 0DAS	17DAS	0DAS
RT (Ncm)	−1.04 ±4.33	1.09 ±4.92	−0.51 ±3.24	−2.57 ±5.11

Table 3: Group comparison of mean ±SD DRT

The one-way ANOVA analysis revealed no significant variations in variances between and within groups for each investigated parameter, as the P value was more than.05, the F value was.800, and the degrees of freedom (df) were three across groups and twenty-four within groups.

There was no evidence of a screw fracture. Screws in group 0GS were tightened to 35 Ncm, whereas screws in group 0DAS and 17DAS were tightened to 25 Ncm, as recommended by the makers. Following that, all screws were tightened to the prescribed torque values before to loading into a dual-axis mastication simulator (CS4-8; SD Mechatronic) with an antagonistic stainless-steel ball and subjecting it to a 45 N axial load for 600000 cycles. At 9205 cycles, all specimens were retightened to compensate for the loss of initial preload caused by settling effects. 15-19 After the dual-axis mastication simulator attained cyclic fatigue.

Conclusion

With the limitation of this study, we noticed that:

- The removal torque value of dynamic abutments is comparable to that of multi-unit abutment.
- Angulation of the abutments had no significant influence on the RTV.

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الملخص

الغرض: كان الغرض من هذه الدراسة في المختبر هو تقييم ومقارنة قيم عزم الإزالة للدعامة الديناميكية والدعامة متعددة الوحدات. على وجه التحديد، دعامة بزاوية 17 درجة ودعامة مستقيمة من كل نوع.

المشكلة: تم إدخال المكونات التي تتيح إمالة القناة اللولبية لتاج الغرسة بشكل لغوي وشد البراغي في اتجاه غير محوري بالنسبة إلى الغرسة. هناك ندرة في المعلومات حول كيفية مقارنة قيمة عزم الدوران للإزالة (RTV) بتلك الموجودة في البراغي العادية.

الطريقة: سيتم استخدام ما مجموعه ثماني تركيبات ودعامة سداسية داخلية للزرع في الدراسة. ستكون المجموعةA ، Bعبارة عن دعامة مستقيمة ومتعددة الوحدات بزاوية. المجموعةC ، D ستكون دعامة ديناميكية مستقيمة وزاوية. يتم تقييم قيمة عزم الإزالة بشكل جيد مرتين. سيتم قياس الفرق بين خط الأساس وعزم الإزالة.

النتائج: لم تكن محطات (RTV) مختلفة بشكل كبير بين المجموعات. لم يتم رؤية كسر في المسمار.

الخلاصة: لم يكن لزاوية الدعامات تأثير كبير علىRTV .

الكلمات المفتاحية: الدعامة، إزالة قيمة عزم الدوران، فك المسمار، زراعة الأسنان، الزاوية.

References

1. Alikhasi, M., Kazemi, M., Jalali, H., Hashemzadeh, S., Dodangeh, H., & Yilmaz, B. (2017). Clinician-generated torque on abutment screws using different hand screwdrivers. The Journal of Prosthetic Dentistry, 118(4), 488-492.
2. Al-Otaibi, H. N., AL-Fouzan, A. F., Al-Mufleh, T. S., & Labban, N. (2018). Effect of different maintenance time of torque application on detorque values of abutment screws in full-arch implant-supported fixed prostheses. Clinical Implant Dentistry and Related Research, 20(5), 848-851.
3. Al-Otaibi, H. N., Almutairi, A., Alfarraj, J., & Algesadi, W. (2017). The Effect of Torque Application Technique on Screw Preload of Implant-Supported Prostheses. International Journal of Oral & Maxillofacial Implants, 32(2).
4. Arshad, M., Mahgoli, H., & Payaminia, L. (2018). Effect of Repeated Screw Joint Closing and Opening Cycles and Cyclic Loading on Abutment Screw Removal Torque and Screw Thread Morphology: Scanning Electron Microscopy Evaluation. International Journal of Oral & Maxillofacial Implants, 33(1).
5. Berroeta, E., Zabalegui, I., Donovan, T., & Chee, W. (2015). Dynamic abutment: a method of redirecting screw access for implant-supported restorations: technical details and a clinical report. The Journal of prosthetic dentistry, 113(6), 516-519.
6. Bulaqi, H. A., Barzegar, A., Paknejad, M., & Safari, H. (2019). Assessment of preload, remaining torque, and removal torque in abutment screws under different frictional conditions: A finite element analysis. The Journal of Prosthetic Dentistry, 121(3), 548-e1.
7. Cavallaro Jr, J., & Greenstein, G. (2011). Angled implant abutments: a practical application of available knowledge. The Journal of the American Dental Association, 142(2), 150-158.
8. Cicciù, M., Cervino, G., Milone, D., & Risitano, G. (2018). FEM investigation of the stress distribution over mandibular bone due to screwed overdenture positioned on dental implants. Materials, 11(9), 1512.
9. Gracis, S., Michalakis, K., Vigolo, P., Vult von Steyern, P., Zwahlen, M., & Sailer, I. (2012). Internal vs. external connections for abutments/reconstructions: a systematic review. Clinical oral implants research, 23, 202-216.
10. GÜRPINAR, B., ÜLKER, G. M. Y., & Önjen, T. A. K. (2020). The Use of Angulated Screw Channel Abutment System for Anterior Single-Implant Restorations: A Clinical Report. European Journal of Research in Dentistry, 4(1), 40-44.
11. Jo, J. Y., Yang, D. S., Huh, J. B., Heo, J. C., Yun, M. J., & Jeong, C. M. (2014). Influence of abutment materials on the implant-abutment joint stability in internal conical connection type implant systems. The Journal of Advanced Prosthodontics, 6(6), 491-497.

12. Jörn, D., Kohorst, P., Besdo, S., Rücker, M., Stiesch, M., & Borchers, L. (2014). Influence of lubricant on screw preload and stresses in a finite element model for a dental implant. The Journal of prosthetic dentistry, 112(2), 340-348.
13. Kao, H. C., Gung, Y. W., Chung, T. F., & Hsu, M. L. (2008). The influence of abutment angulation on micromotion level for immediately loaded dental implants: a 3-D finite element analysis. International Journal of Oral & Maxillofacial Implants, 23(4).
14. Karunagaran, S., Paprocki, G. J., Wicks, R., & Markose, S. (2013). A review of implant abutments--abutment classification to aid prosthetic selection. The Journal of the Tennessee Dental Association, 93(2), 18-23.
15. Kim, K. S., & Lim, Y. J. (2020). Axial displacements and removal torque changes of five different implant-abutment connections under static vertical loading. Materials, 13(3), 699.
16. Krishnan, V., Tony Thomas, C., & Sabu, I. (2014). Management of abutment screw loosening: Review of literature and report of a case. The Journal of Indian Prosthodontic Society, 14(3), 208-214.
17. Lee, A., Okayasu, K., & Wang, H. L. (2010). Screw-versus cement-retained implant restorations: current concepts. Implant dentistry, 19(1), 8-15.
18. Lee, H. J., Park, Y. U., Kim, S. J., & Kim, H. N. (2021). Screw stripping and its prevention in the hexagonal socket of 3.5-mm titanium locking screws. Scientific Reports, 11(1), 1-8.
19. Lee, J. H., & Cha, H. S. (2018). Screw loosening and changes in removal torque relative to abutment screw length in a dental implant with external abutment connection after oblique cyclic loading. The Journal of Advanced Prosthodontics, 10(6), 415-421.
20. Levin, L. (2020). Nonsurgical and surgical management of biologic complications around dental implants: Peri-implant mucositis and peri-implantitis. Quintessence International, 51(10), 810-820.
21. Ma, S., & Fenton, A. (2015). Screw-versus cement-retained implant prostheses: a systematic review of prosthodontic maintenance and complications. International Journal of Prosthodontics, 28(2).
22. Misch, C. E. (2014). Rationale for dental implants. Dental implant prosthetics. 2nd ed. St. Louis (MO): Elsevier, 1-25.
23. Misch, C. E. (2015). Principles for abutment and prosthetic screws and screw-retained components and prostheses. In Dental Implant Prosthetics (pp. 724-752). Mosby.
24. Misch, C. E., & Resnik, R. (2017). Misch's Avoiding Complications in Oral Implantology. Elsevier Health Sciences.
25. Niinomi, M., & Boehlert, C. J. (2015). Titanium alloys for biomedical applications. In Advances in metallic biomaterials (pp. 179-213). Springer, Berlin, Heidelberg.
26. Olate, S., Lyrio, M. C. N., de Moraes, M., Mazzonetto, R., & Moreira, R. W. F. (2010). Influence of diameter and length of implant on early dental implant failure. Journal of Oral and Maxillofacial surgery, 68(2), 414-419.

27. Park, J. K., Choi, J. U., Jeon, Y. C., Choi, K. S., & Jeong, C. M. (2010). Effects of abutment screw coating on implant preload. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry, 19(6), 458-464.
28. Sailer, I., Mühlemann, S., Zwahlen, M., Hämmerle, C. H., & Schneider, D. (2012). Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates. Clinical oral implants research, 23, 163-201.
29. Shadid, R., & Sadaqa, N. (2012). A comparison between screw-and cement-retained implant prostheses. A literature reviews. Journal of Oral Implantology, 38(3), 298-307.
30. Shafie, H. R. (2014). Clinical and laboratory manual of dental implant abutments. John Wiley & Sons.
31. Sherif, S., Susarla, H. K., Kapos, T., Munoz, D., Chang, B. M., & Wright, R. F. (2014). A systematic review of screw-versus cement-retained implant-supported fixed restorations. Journal of Prosthodontics, 23(1), 1-9.
32. Tian, K., Chen, J., Han, L., Yang, J., Huang, W., & Wu, D. (2012). Angled abutments result in increased or decreased stress on surrounding bone of single-unit dental implants: a finite element analysis. Medical engineering & physics, 34(10), 1526-1531.
33. Turkoglu, P., Kose, A., & Sen, D. (2019). Abutment selection for anterior implant-supported restorations. In An Update of Dental Implantology and Biomaterial. Intechopen.
34. Vigolo, P., Mutinelli, S., Givani, A., & Stellini, E. (2012). Cemented versus screw-retained implant-supported single-tooth crowns: a 10-year randomized controlled trial. Eur J Oral Implantol, 5(4), 355-64.
35. Vindašiūtė-Narbutė, E. (2018). Factors associated with removal of the cement excess in implant-supported (Doctoral dissertation, Vilniaus universitetas).
36. Wadhwani, C. P., & Faber, T. D. (2015). Residual excess cement detection. In Cementation in Dental Implantology (pp. 83-99). Springer, Berlin, Heidelberg.
37. Wadhwani, C., & Piñeyro, A. (2009). Technique for controlling the cement for an implant crown. The Journal of prosthetic dentistry, 102(1), 57-58.
38. Walton, T. R., & Layton, D. M. (2017). Satisfaction and Patient-Related Outcomes in 128 Patients with Single Implant Crowns in Situ for up to 14 Years. International Journal of Oral & Maxillofacial Implants, 32(3).
39. Wang, J. H., Judge, R., & Bailey, D. A. (2016). 5-year retrospective assay of implant treatments and complications in private practice: the restorative complications of single and short-span implant-supported fixed prostheses. Int J Prosthodont, 29(5), 435-444.
40. Wittneben, J. G., Joda, T., Weber, H. P., & Brägger, U. (2017). Screw retained vs. cement retained implant-supported fixed dental prosthesis. Periodontology 2000, 73(1), 141-151.
41. Wu, T., Liao, W., Dai, N., & Tang, C. (2010). Design of a custom angled abutment for dental implants using computer-aided design and nonlinear finite element analysis. Journal of biomechanics, 43(10), 1941-1946.

42. Zhou, C. G., Feng, H. T., Chen, Z. T., & Ou, Y. (2016). Correlation between preload and no-load drag torque of ball screws. International Journal of Machine Tools and Manufacture, 102, 35-40.