An *In Vitro* Analysis of Implant Screw Torque Loss With External Hex and Internal Connection Implant Systems

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Purpose: *The purpose of this study was to examine, in a controlled environment, effects of connection design upon screw stability. Implant fixtures have 2 types of connections to the abutment: internal connection and external hex. Four implant systems were tested: Bio-Lok (external hex; Bio-Lok International, Inc., Deerfield Beach, FL); Zimmer (internal connection; Zimmer Dental, Carlsbad, CA); Nobel Biocare (external hex; Nobel Biocare USA, Inc., Yorba Linda, CA); and Astra Tech (internal connection; Astra Tech Inc., Waltham, MA).*

Materials and Methods: *Ten samples of each system, including base, implant, abutment, and molar crown, were loaded to 200 N for* 1×10^6 *cycles. Screws were tightened to manufacturers' recommendations, and torque audits done at* 2.5×10^5, 5×10^5, 7.5×10^5, *and* 1×10^6 *cycles.*

Results: *The Bio-Lok samples lost an average of 10% of the original torque values, the Astra Tech group lost almost all of the torque and loosened, while the Zimmer and Nobel Biocare samples lost an average of 50% of the torque but did not loosen* ($P \leq 0.05$)*.*

Conclusions: *It may be concluded from this study that although internal connections are clinically favored, this study did not show any advantage relative to screw loosening. However, screw design may be a significant factor in loosening of the joint. (Implant Dent 2006;15:427–435)*

Key Words: implant, internal connection, external hex, screw loosening

The screw is an important component of the implant-supported restoration. Loosening of the screw may result in displacement of the prosthesis and certainly causes loss of prosthetic function.[1] Screw loosening has been reported to occur most often with single-tooth implant restorations but has also been reported in multiple-unit situations.[2] Suggestions to maintain a tight screw connection include anti-vibrational thread compounds, direct mechanical interlocks, changes in screw design, and torque-controlling mechanisms.[3] All of these approaches have helped minimize the screw loosening problem. None, however, has eliminated the problem completely. Clinical studies report that between 6% and 31% of the screws were loose at the first post-insertion visit.[4–6] An increased incidence of loosening was reported for restorations in the premolar area compared to incisor.[7,8] However, these differences may be the result of the variations in prosthetic design as well as in masticatory force.

Torquing the abutment screw joins together the interfaces of the abutment and implant into a unit called the screw joint. The screw loosens only if forces acting to separate the screw joint are greater than the forces keeping the abutment and implant together.[9]

The force holding the abutment and implant together is called the clamping force. Thus, to maintain the joint, the separating forces must be less than the threshold of the established clamping force. If the joint does not open when a force is applied, the screw does not loosen.[10] To keep abutment screws tight, the clamping force must be maximized, and joint-separating forces should be reduced. An often used clinical strategy is to narrow the occlusal table.[11]

Preload is the tension induced in a screw when torque is applied. Preload keeps the screw threads tightly secured to the internal aspect of the implant threads, and holds the screw head and its seat together.[12] The screw elongates, placing the shank and threads in tension. The elastic recovery of the screw creates the clamping force that pulls the prosthesis and implant together.[13]

There are several mechanisms that can cause screw loosening and loss of preload. One is the embedment relaxation of mating thread surfaces.[14] New screws and bolts all possess some rough-textured thread surfaces as a result of the machining process. When the torque is applied, energy is dissipated in smoothing mating surfaces,

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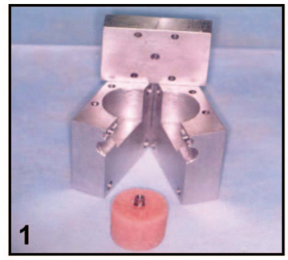
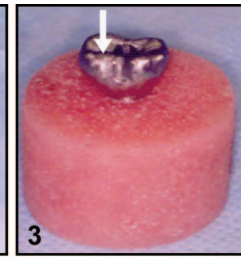
reducing the elongation of the screw. Embedment relaxation of mating surfaces results from the fact that, because of machining microroughness, no 2 surfaces are in complete contact with one another.[15] Thus, during loading (*i.e.,* settling), closer adaptation of the threads will occur because the screw-implant interface experiences micromovement and wear of the contact surfaces. Rough surfaces and large external loads tend to increase this effect and result in greater settling.[16] Ten percent of initial preload can be lost because of embedment relaxation.

A second mechanism is reduction in preload, resulting either from tightening friction or distortion of the screw material. Efforts are being made to minimize loss of input torque due to friction.[17] Abutments screws generally consist of a flat head seat, a long stem length, and 6 threads. In the original design, the stem stretched elastically, generating a preload. A lesser number of threads reduces friction. Additional threads are superfluous since the first 3 threads carry most of the load.[14] Flat-head screws, by virtue of reduced surface contact, generate significantly less frictional resistance when tightened than screws with bevels or tapers.[18] When less input torque is lost to friction and heat, more is transferred into usable preload. Consequently, flat-head screws always have a higher preload at any given torque range than tapered or beveled screws and are, therefore, more stable.[19] In addition, thread friction is higher for the first tightening and loosening of a screw. This reduces the amount of the torque that translates into preload. After repeated tightening and loosening cycles, friction decreases as the surfaces become smoother. As a result, preload initially increases, then levels out. About 90% of input torque is used to overcome friction and only 10% to induce preload.[20]

Material strength has a significant influence on preload.[16] The yield strength of the material is important to the maintenance of the preload. Typically, the manufacturer of threaded fasteners will recommend tightening to only 75% to 80% of the yield strength as a buffer to prevent permanent deformation. However, the stronger the screw, the greater the preload that can be achieved. This is true only within certain limits since after some point when tightening the screw, the friction between the implant threads and the screw threads is so great that the hex will strip or the tightening wrench will break. Friction is also increased by “galling,” a form of adhesive wear that occurs during the intimate sliding contact of 2 like materials. As the friction increases, metal rubs off one surface and sticks to the other surface, and binds the materials together.[21] However gold-alloy screws, which have a much lower coefficient of friction, can be tightened more effectively to higher preloads and will not stick to titanium. A gold-alloy screw can attain preloads of more than 890 N at approximately 75% of its yield strength.[14]

Previous research has demonstrated that off-axis loading may result in screw and abutment deformation and counterclockwise rotation that were associated with loss of screw tightness.[22] However, the effects of implant abutment-connection type and differences in screw design were not studied. The purpose of this study was to investigate the effects of implant abutment-connection and screw design upon screw tightness with long-term, off-axis loading. The null hypothesis of the study is that there is no correlation between differences in joint and screw design, and the stability of the screw joint.





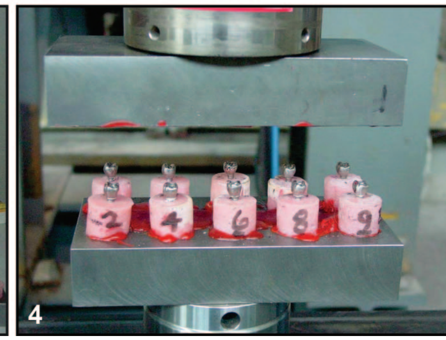


Fig. 1. Standardized aluminum mold for embedding implants in resin blocks.

Fig. 2. Torque monitoring system consisting of a torque meter for measuring the remaining torque and a linked RVIT for measuring the screw rotation associated with the torque level attached to a rigid frame. Implant drivers were rigidly attached to the shaft of the torque meter, and lowered through the access hole in the crowns and inserted into the screw to monitor the abutment screw torque.

Fig. 3. Specimen consisting of a resin block in which a 4 × 10 mm implant is embedded. A standardized custom abutment was screwed to the implant using the manufacturer’s recommended torque and a cast crown cemented to the abutment. Note that there is an access hole through the crown to monitor the torque of the abutment screw. A 32-Ncm torque.

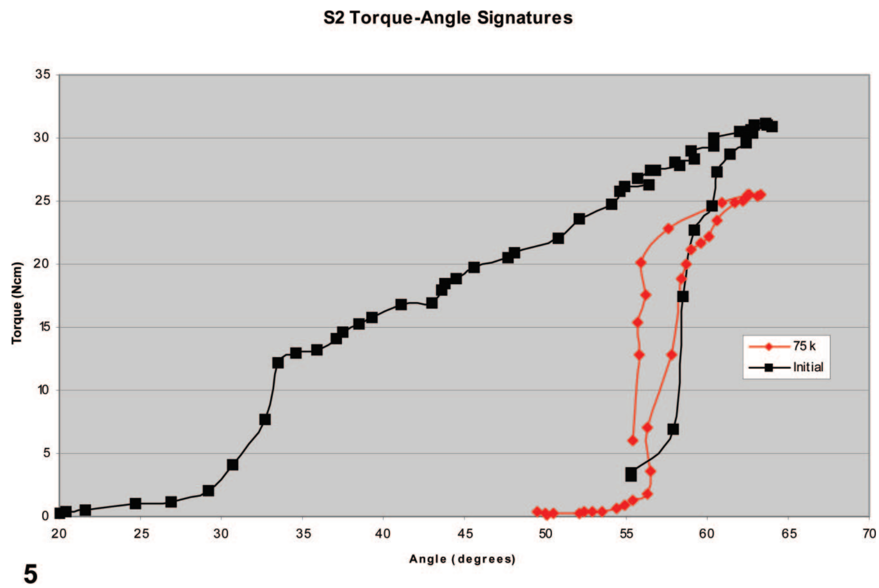
Fig. 4. The MTS system with 10 samples inserted into the stainless steel block attached to the lower platen and the stainless steel block with a resin insert attached to the upper platen prepared for loading.

Materials and Methods

Four implant systems were tested: Brånemark (Nobel BioCare, Yorba Linda, CA); Bio-Lok (Bio-Lok International, Inc., Deerfield Beach, FL); Astra Tech (Astra Tech Inc., Waltham MA); and Screw-vent (Zimmer Dental, Carlsbad, CA). For each system, 10 samples were prepared by embedding, to the level of the collar, a 4.0 × 10 mm long implant in a polymethyl, methacrylate block (Repair Resin; DENTSPLY Int., York, PA) made in a stainless steel split mold (Fig. 1). The blocks were designed to fit into recesses in a stainless steel form 14 inches long, 5 inches wide, and 2.5 inches thick. The under side of the form was tapped to attach to the lower platen on an MTS4600 unit (MTS System Corp., Eden Prairie, MN). For each sample, abutments were placed and tightened to 32 Ncm using a Lucas RVIT and a CDI Torque Meter (CDI Torque Products, City of Industry, CA) (Fig. 2). Standardized alloy molar crowns, 11 mm mesiodistally, 9 mm buccolingually, 8 mm occluso-gingivally, were cast and fitted for each of the samples using a waxup generated from a split-mold made from a diagnostic waxup (Maestro; Heraeus-Kulzer, Armonk, NY). Holes through the occlusal surfaces were prepared to allow access to the abutment. Each of the crowns was cemented (Temp Bond; Kerr Corp., Orange, CA) on its abutment, and the 10 samples of the 4 groups were each numbered (Fig. 3).

At random, 10 samples were selected from the 4 groups and placed in the recessed stainless steel form that was subsequently attached to the lower platen of the MTS System. A metal block 14 inches long, 5 inches with and 2.5 inches thick with a central cutout facing downward was attached to the upper platen. After being filled with a polymethyl methacrylate monomer-polymer mixture and before polymerization was complete, the block attached to the upper platen, was lowered onto the crowns and allowed to polymerize. Following polymerization, the resin in the block attached to the upper platen was equilibrated such that only the mesiobuccal cusp contacts the resin (Fig. 4). The occlusal contacts were equilibrated to contact with equal load using the Tekscan II system (Tekscan, Inc., Boston, MA).

Prior to loading, torque audits were done with the RVIT/CD unit to ensure that all screws were tightened to 32 Ncm. Samples were loaded vertically with 200 N at a rate of 10 Hz on the MB cusp. This contact was 4 mm offset from the central axis of the implant (Fig. 4). After 250,000 cycles, torque audits were done for all 10 samples in the block. Following this, the cycling was resumed. Additional torque audits were done at 500,000, 750,000, and 1,000,000 cycles (Fig. 5).



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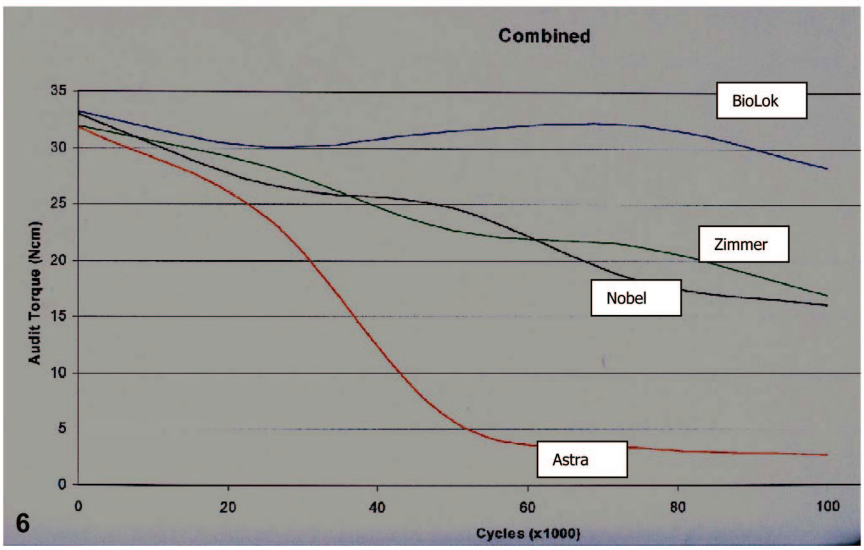

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Fig. 5. Example of a torque signature audit. The x axis represents the degrees of screw rotation, while the y axis represents the torque values.

Fig. 6. Plot of the torque audits of the abutment screws for Bio-Lok, Zimmer, Nobel Biocare, and Astra Tech monitored for 1 million cycles. Torque audits were done at 250,00, 500,000, 750,000, and 1,000,000 cycles.

If screw loosening was observed, the screws were not retightened but were further loaded for the next series of cycles. At the completion of the 1,000,000 cycles for the first 10 samples, a second randomized set of samples was mounted in the block attached to the lower platen, and the process was repeated. Four series of loading trials were required to complete the 40 samples.

Statistical Analysis

For each of the 4 groups, the torque signatures of the 10 samples at each of the torque audits were analyzed, and means and standard deviations (SDs) obtained. The statistics were compared using a 1-factor analysis of variance (implant system), and post hoc comparisons were done using the Scheffe test.

Results

Means and SDs were calculated for the 4 systems at each of the torque audits of 0, 250,000, 500,000, 750,000, and 1,000,000 cycles (Table 1). The findings for each of the systems are described below.

Table 1. The Torque Values of the Different Implant Systems Observed by Torque Audit for Different Cycles of Loading

Torque Audits	Zero Cycles	250,000 Cycles	500,000 Cycles	750,000 Cycles	1,000,000 Cycles
Bio-Lok	32.04 (0.08)	31.00 (1.33)	31.00 (1.33)	32.10 (0.32)	28.30 (6.62)
Nobel Biocare	32.0 (0)	28.80 (5.53)	24.20 (6.48)	18.20 (8.96)	16.10 (7.82)
Zimmer	32.0 (0)	28.40 (4.45)	22.70 (6.53)	21.10 (6.70)	16.90 (8.76)
Astra Tech	29.29 (9.02)	25.30 (5.60)	5.80 (8.03)	3.40 (7.23)	2.70 (5.74)

Values are expressed as the mean (SD).

Bio-Lok

Bio-Lok abutment screws (external connection) maintained their tightness the best of the 4 systems over the 1,000,000 loading cycles ($P \leq 0.05$). There was only a mean loss of 12% of the torque during the testing period. The torque loss for the Bio-Lok system was significantly less than the Astra Tech and Nobel Biocare implant systems for the 250,000, 500,000, 750,000, and 1,000,000 cycle torque audits ($P \leq 0.05$), and significantly less than the Zimmer system at the 500,000 and 1,000,000 cycle torque audits ($P \leq 0.05$).

Zimmer

Zimmer abutment screws (internal connection) lost approximately 25% of the torque at 500,000 cycles. At 1,000,000 cycles, 50% of the torque was lost. The Zimmer system was statistically different from that of the Astra Tech system at the 250,000 cycle, 500,000 cycle and 1,000,000 cycle audits ($P \leq 0.05$). It was statistically different from the Bio-Lok system at 500,000 and 1,000,000 cycle audits. It was similar to the Nobel Biocare system at the 250,000, 500,000, and 750,000 cycle torque audits.

Nobel Biocare

Nobel Biocare abutment screws (external connection) had similar results as those observed with the Zimmer abutment screw systems, losing up to 50% of the torque by 1,000,000 cycles. There was no statistical difference between the torque audits of the Nobel Biocare and Zimmer systems. This system was different than both the Bio-Lok and Astra Tech systems at the 250,000, 500,000, and 750,000 cycle torque audits ($P \leq 0.05$).

Astra Tech

Astra Tech abutment screws (internal connection) lost about 90% of their torque. Eight of the 10 Astra Tech screws were found to loosen completely. The mean torque on the 2 screws that did not loosen completely was 13.5 Ncm. The torque loss of the Astra Tech system was greater than that of all the other 3 systems ($P \leq 0.5$).

Discussion

In this study, monitoring of screw torque provided a clearer understanding of the role of the screw and the significance of implant design on its maintenance preload. Regarding implant design, there was no difference seen between the behavior of the internal connection and external hex implant systems. Interestingly, the Nobel Biocare implant with an external hex and the Zimmer implant with an internal connection performed similarly with regards to loss of torque ($P \leq 0.05$). However, in contrast, the Bio-Lok system with an external hex showed the least amount of torque loss ($P \leq 0.05$), while Astra Tech with an internal connection showed the greatest amount ($P \leq 0.05$) (Fig. 6).

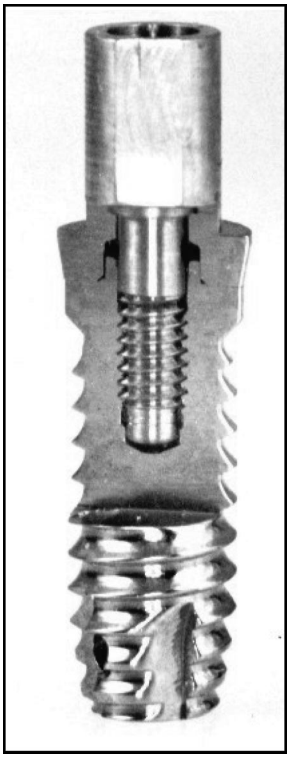

Fig. 7. Bio-Lok screw in cross section. The journal is present at the base of the screw.

The results of this study suggest the importance of screw design on the stability of the screw and maintenance of preload.[14] The Bio-Lok system, utilizing a screw with a short thick shank and with a journal design, demonstrated less torque loss. The design of the Bio-Lok screw with its increased stiffness seems to resist effectively joint opening forces. The Bio-Lok screw utilizes a journal to provide increased stability against lateral occlusal forces (Fig. 7). A journal is a smooth diameter machined on the end of the screw. The Bio-Lok journal is a 2-mm long extension of the screw that rests within the base of the implant body. The journal fits in an intimate manner within the walls of the implant, resisting lateral movement and bending of the joint. This screw differs from the other 3 systems that have a screw with a long narrow shank and do not have a journal. As noted previously, the effectiveness of the screw is a function of tightening torque and the amount of preload generated.[23] Applying torque tightens the screw and, thus, maintains the stability of the joint. However, not all the torque is utilized for joint stability, as some is lost in overcoming friction and irregularities in the mating surfaces. The result is a lower clamping force. Large bending forces can cause screw loosening, further reducing the clamping force.

In this study, preload was not measured directly. Torque auditing is a method to evaluate the stability of the joint by auditing or testing the tightness of the screw.[16] The process consists of an operator advancing the screw very slightly (range 5°-10°) in a tightening direction and observing the initial torque value using an electronic torque meter (Fig. 5). If the initial torque value to which the screw was tightened is known, as is true for abutment screws, the audit can provide information regarding the residual torque and, thus, the potential for loosening of the joint. This technique is a well-accepted approach in engineering technology.[3] These audits measured the difference between the original torque (32 Ncm) and that observed after loading. While a loss of torque may not immediately reflect itself in evident loosening of the joint, if the process is allowed to continue, it may result in frank instability of the joint with concurrent separation of abutment from the implant.[14] However, only one of the systems tested, Astra Tech, showed this type of loosening. The other systems, Bio-Lok, Nobel Biocare, and Zimmer, did not show any separation of the joint. In a study of the CeraOne system (Nobel Biocare), Anderson *et al*[24] showed a similar behavior in that there was a loss of torque but no separation of the joint. Interestingly, in that study, the screws were shown to be bent. Even partial loss of torque appears to require some screw loosening.

In a previous publication,[25] we substantiated Junker's[26] of screw loosening for dental implant systems by demonstrating counterclockwise rotation of the screw after loading. Junker's theory hypothesizes that flexure at the joint interface results in a momentary loss of preload that in turn allows slight counterclockwise rotation of the screw. If this occurs periodically it can result in a loss of the joint clamping force that increases with an increasing number of flexures at the joint.[27] This hypothesis would explain the loss of torque seen in this research as well. This *in vitro* experiment differs from the clinical situation. The off-axis forces generated by the MTS System may be larger than those seen clinically. Nevertheless, these experiments are relevant, as testing of these systems at their functional limit is important because of the necessity of implant systems to function for the life expectancy of the patient. This experimental design has provided significant information, in that it appears that for 3 of the 4 systems tested, with both external hex and internal connection, joint stability was maintained in spite of some loss of torque. The fourth system, which had excessive torque loss, has demonstrated excellent clinical performance, although it may be possible that there may be some long-term problems associated with this particular design that have not yet been identified.

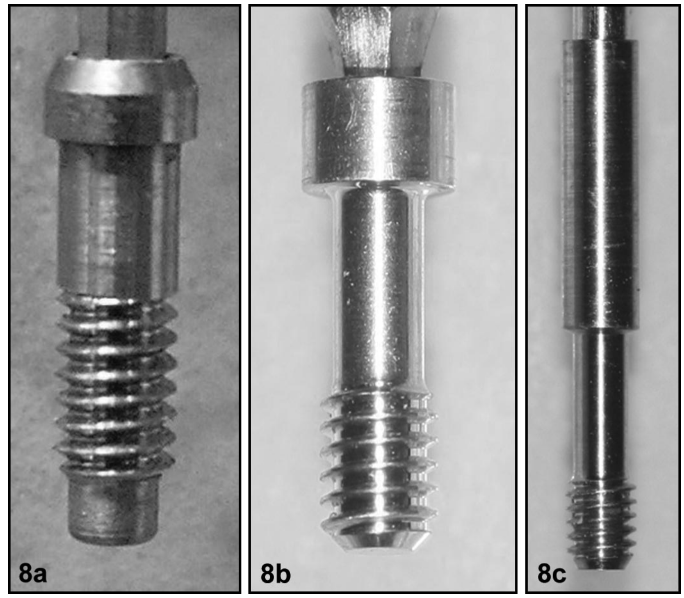

Fig. 8. Representative screws: Bio-Lok, Zimmer, and Nobel Biocare (left to right). Note the differences in screw design between the Bio-Lok screw with a thick shank, and the Zimmer and Nobel Biocare screws with thinner shanks.

An effective method to reduce screw loosening is to increase the screw preload and clamping force across the joint to ensure that the screw preload and clamping force are greater than the occlusal forces acting on the implant system. The maximum preload has been calculated to be a maximum of 75% of the strength of the screw. Screw strength is significantly related to the modulus of elasticity of the material from which the screw is manufactured. The values of 32-35 Ncm were established based upon gold screws made from materials with low moduli and yield strengths.[16] With more advanced technologies available today, perhaps it is time to reconsider these torque values. The criteria for screw torque should be based on: (1) the occlusal forces loading the prosthesis and (2) the strength of the osseointegrated bone-implant interface. To date, variations in screw designs improved manufacturing tolerances, and coatings on the screws have been utilized to increase the preload (Fig. 8).[14] One aspect of the problem that should be considered is the use of higher torque values. With some of the more current screw designs, torque values of 40 and perhaps 50 Ncm may be possible without plastic deformation.[25] Use of higher torque values would increase the preload, and provide increased resistance to joint separation and greater screw stability. This approach requires further consideration. In addition, further evidence-based research is needed to correlate the results of these experiments with clinical performance. Clinical performance of any implant system is associated with a variety of factors, including osseointegration, the occlusion, saliva, jaw movement, and bone quality, which are difficult to reproduce in an experimental design. In addition, there are a number of individual factors that vary from patient to patient and may have significant impact on the long-term prognosis of implant-supported restorations. In summary, the screw would appear to be the keystone of the 2-piece implant system. Enhancements in design and material characteristics should be studied to improve further the predictability and stability of the joints of current implant systems.

Conclusions

This *in vitro* study examined the relationship between the abutment implant joint, the screw design, and the torque values stabilizing the joint. The experimental parameters (*i.e.,* a 200-N load applied 6 mm from the long axis of the implant) approach both the maximum occlusal force that is applied, and the morphology and size of the dentition. The findings from this study suggest that the design of the joint (*i.e.,* internal *vs.* external connections) was not a significant factor in loss of torque. What did appear important was the screw design. Use of a screw with a thick stem and a journal provided the least loss of torque and, thus, greatest joint stability. These findings may have clinical significance, particularly in the bruxing patient or for individuals in which implant placement may not have been ideal.

Disclosure

The authors claim to have no financial interest in any company or any of the products mentioned in this article.

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ID Abstract Translations

GERMAN / DEUTSCH

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Eine Laborstudie zum Drehmomentverlust von Implantatschrauben bei externen Hex-Implantatsystemen und internen Verbindungs-Implantierungssystemen

ZUSAMMENFASSUNG: Zielsetzung: Diese Analyse war darauf ausgerichtet, in einer kontrollierten Umgebung die Auswirkungen des Verbindungsdesigns auf die Schraubstabilität zu untersuchen. Implantatbefestigungen können auf zwei verschiedene Arten mit dem Stützapparat verbunden werden - mittels interner Verbindung (iV) oder externer Hex (eH). Im Test wurden vier unterschiedliche Implantierungssysteme untersucht – BioLok (eH), Zimmer (iV), NobelBiocare (eH), AstraTech (iV). ***Materialien und Methoden:*** Zehn Probestücke aus jedem der Systeme (inkl. Basis, Implantat, Stützzahnapparat, Molarkrone) wurden mit bis zu 200 N über 1×10^6 Zyklen belastet. Die Schrauben wurden entsprechend Herstellerempfehlung festgezogen. Bei 2.5×10^5, 5×10^5, 7.5×10^5, and 1×10^6 Zyklen wurden Drehmomentprüfungen durchgeführt. ***Ergebnisse:*** Die BioLok-Prüfmodelle verloren durchschnittlich nur 10% der ursprünglichen Drehmomentleistung, während bei der aus AstraTech-Produkten bestehenden Testgruppe ein Verlust fast des gesamten Drehmoments mit Lockerung zu verzeichnen war. Die Prüfteile von Zimmer und NobelBiocare verloren zwar ebenfalls durchschnittlich 50% an Drehmoment, wurden dabei aber nicht locker, $p < 0{,}05$. ***Schlussfolgerungen:*** Die vorgenommene Studie lässt den Schluss zu, dass interne Verbindungen zwar in der klinischen Nutzung bevorzugt werden, sich aber keinerlei Hinweis darauf findet, dass sie sich in Bezug auf die Lockerung der Verschraubung vorteilhaft verhalten. Das Schraubendesign kann allerdings bei einer möglichen Lockerung des Gelenks eine maßgebliche Rolle spielen.

SCHLÜSSELWÖRTER: Implantat, interne Verbindung, externe Hex, Lockerung der Verschraubung

SPANISH / ESPAÑOL

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Un análisis in vitro de la pérdida de torsión del tornillo del implante con sistemas de implantes con conexión interna y hexágonos externos

ABSTRACTO: Propósito: El propósito de este estudio fue examinar, en un ambiente controlado, los efectos del diseño de la conexión en la estabilidad del tornillo. Los implantes tienen dos tipos de conexiones al pilar: la conexión interna (ic) y los hexágonos externos (eh). Se probaron cuatro sistemas de implantes – BioLok (eh), Zimmer (ic), NobelBiocare (eh), AstraTech (ic). ***Materiales y métodos:*** Se cargaron diez muestras de cada sistema (incluyendo la base, el implante, el pilar, la corona molar) hasta 200 N durante 1×10^6 ciclos. Los tornillos se ajustaron según las recomendaciones de los fabricantes y se realizaron auditorías de la torsión en los ciclos 2.5×10^5, 5×10^5, 7.5×10^5, y 1×10^6. ***Resultados:*** Las muestras BioLok perdieron un promedio del 10% de los valores de torsión originales, el grupo AstraTech perdió casi toda la torsión y se aflojó mientras que las muestras Zimmer y NobelBiocare perdieron un promedio del 50% de la torsión pero no se aflojaron, $p < 0.05$. ***Conclusiones:*** Se puede concluir de este estudio que a pesar de que las conexiones internas son clínicamente favorecidas, este estudio no demostró ninguna ventaja con respecto al aflojamiento del tornillo. Sin embargo, el diseño del tornillo puede ser un factor significativo en el aflojamiento de la unión.

PALABRAS CLAVES: Implante, conexión interna, hexágono externo, aflojamiento del tornillo

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Uma Análise In Vitro da Perda de Torção do Parafuso de Implante com Sistemas de Implantes de Hex Externo e Conexão Interna

RESUMO: Objetivo: O objetivo deste estudo era examinar, num ambiente controlado, efeitos do projeto de conexão na estabilidade do parafuso. A aparelhagem do implante tem dois tipos de conexões com o suporte – conexão interna (ic) e hex externo (eh). Quatro sistemas de implante foram testados – BioLok (eh), Zimmer (ic), NobelBiocare (eh), AstraTech (ic). ***Materiais e Métodos:*** Dez amostras de cada sistema (incluindo base, implante, suporte, coroa molar) foram carregados a 200 N para 1×10^6 ciclos. Os parafusos foram apertados segundo as recomendações dos fabricantes e as medições de torção feitas a ciclos de 2.5×10^5, 5×10^5, 7.5×10^5, e 1×10^6. ***Resultados:*** As amostras de BioLok perderam um média de 10% dos valores de torção originais, os grupo AstraTech perdeu quase toda a torção e afrouxou, enquanto as amostras Zimmer e NobelBiocare perderam uma média de 50% da torção, mas não afrouxou, $p < 0.05$. ***Conclusões:*** Pode-se concluir deste estudo que, embora as conexões internas sejam clinicamente favorecidas, este estudo não mostrou nenhuma vantagem relativa ao afrouxamento do parafuso. Contudo, o projeto do parafuso pode ser um fator significativo no afrouxamento do encaixe.

PALAVRAS-CHAVE: Implante, conexão interna, hex externo, afrouxamento do parafuso

JAPANESE / 日本語

External HexとInternal Connectionインプラントシステムにおけるインプラントスクリューのトルクロスの試験管内分析

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要約：

目的：本研究の目的は、結合デザインがスクリューの安定に与える影響をcontrolled environment内で調べることにあった。インプラントfixtureのアバットメント結合部には、internal connection (ic)とexternal hex (eh)の2種類がある。ここではBioLok (eh)、Zimmer (ic)、NobelBiocare (eh)、AstraTech (ic)の4つのインプラントシステムが調べられた。

素材と方法：各システムごとに10のサンプル（ベース、インプラント、アバットメント、モーラー・クラウンを含む）を、200Nで1×10^6サイクルまで荷重した。スクリューはメーカー指定の強さに締め、2.5×10^5、5×10^5、7.5×10^5、1×10^6サイクルにおいてトルクを確認した。

結果：BioLokサンプルは初期トルク数値の平均10%を失った。AstraTech群は全トルクを失い緩んでしまったが、ZimmerとNobelBiocareは平均50%のトルク損失がったにもかかわらず緩まなかった（$p \leq 0.05$）。

結論：本研究の結果から、internal connectionは臨床的に望ましいかもしれないが、スクリューの緩みに関しては何の利点もないという結論が得られよう。しかし、スクリューのデザインが結合部の緩みの有力な要因となることは考えられる。

キーワード： インプラント、internal connection、external hex、スクリューの緩み

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CHINESE / 中国語

外六角螺釘與內接植體系統的試管內植體螺釘扭力損失分析

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摘要：

*目的：*本研究的目的旨在檢查，在受控環境下連接設計對螺釘穩定性的影響。植牙體部和支柱牙有兩種連接類型 – 內接（internal connection，ic）與外六角螺釘（external hex，eh）。合計試驗BioLok (eh)、Zimmer (ic)、 NobelBiocare (eh)、AstraTech (ic) 等4種植體系統。

*資料與方法：*每種系統10個樣本（包括基座、植體、支柱牙、臼齒齒冠），以扭力200牛頓米轉動1 X106 次 。根據製造商的建議鎖緊螺釘，在轉動2.5 X 105、5 X 105、7.5 X 105與 1 X 106 次時稽查扭力結果。

*結果：*BioLok 樣本平均損失原始扭力值的 10%，AstraTech 組損失幾乎所有扭力並產生鬆脫現象，而Zimmer 與 NobelBiocare 樣本則平均損失 50% 扭力，但未鬆脫；$p<0.05$。

*結論：*根據本研究的結果可能可以推論，雖然臨床偏好內接法，但針對螺釘鬆脫現象，本研究並未發現內接法的任何優勢。然而，就接點鬆脫而言，螺釘的設計可能是一項顯著因素。

*關鍵字：*植體、內接、外六角螺釘、螺釘鬆脫

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