Study of the abutment screw threads of Internal Hexagon and Morse Taper Connection Implants and their loosening after Fatigue Testing

ABSTRACT

Aims: This in *vitro* study aimed to evaluate the length of the thread portion and the distance between the thread pitches of internal hexagon (IH) and morse taper (MT) connection screws and their loosening after fatigue testing.
Methodology: Ten IH and ten MT implants received abutments torqued 20 N.cm. The implant-abutment sets were subjected to fatigue by mechanical cycling. After testing the removal torque of the abutments was measured and the abutments and screws were analyzed by scanning electron microscopy.
Results: Student's t-test showed there was no significant difference between the removal torque values among the groups (p=0.609). The length of the screw thread portion of the IH connection was significantly longer than that of the MT connection (p<0.001). There was no significant difference between the groups regarding the distance between the threads of the screws. (p=0.734).
Conclusion: It was concluded that the portion of the threads of the IH connection screws was larger than the MT connection screws. The distance of the thread pitch and the removal torque under fatigue tests were similar in the screws of both connections.

Comment [FE1]: repeated term

Comment [FE2]: I suggest removing it, there is already a "Conclusion" topic

Keywords: Osseointegrated Implants, Osseointegration, Prostheses and Implants, Torque, Fatigue, Bone-Anchored Prosthesis.

1. INTRODUCTION

Osseointegrated implants have changed the planning and treatment of oral rehabilitations for both fully and partially edentulous patients, revolutionizing prosthetic treatment and popularizing implant prostheses[1,2].

Comment [FE3]: I suggest describing this paragraph better. What was the problem that motivated this research?

To be considered functional and adequate, the implants should possess some requirements such as biocompatibility, osseointegration, absence of damage to adjacent structures, and the ability to transmit forces to the bone while respecting physiological limits[3,4]. However, mechanical and biological failures in prostheses over implants often compromise patients' function and well-being[5–8].

Screw loosening is considered one of the most frequent complications reported in single implant prostheses and some of the causes are insufficient torque, inadequate prosthesis fabrication, abutment seating, excessive loading, and screw design have been reported[9,10].

The connection systems of the implant-abutment complex have already demonstrated that screw loosening would be more prevalent in those with external connection[11–14]. On the other hand, internal hexagon connections seem to demonstrate better interface sealing, force distribution, greater stability, and resistance to lateral forces[11–14]. Also compared to the external hexagon system, morse cone platforms have shown less loosening and screw fractures[15,16].

An important mechanical factor that prevents screw loosening and its fracture is the preload, defined as a stress generated in the abutment screw when torque is applied[17]. However, in this process, friction on the screw threads can result in lower preloads [9,15,18,19].

Some parameters affect the preload: the magnitude of the torque, the shape of the screw head, the shape and number of threads, the metal composition, the surface condition, and the screw diameter[20].

Based on the aspects pointed out, this study aimed to evaluate the length of the thread portion and the distance between the thread pitches of screws of internal hexagon and morse taper connections and their torque loss after fatigue tests.

Comment [FE4]: Insert the study hypotheses.

2. MATERIAL AND METHODS

10 internal hexagon connection (Titamax II Plus, Neodent, Curitiba, PR, Brazil) and 10 morse taper connection (Titamax CM, Neodent, Curitiba, PR, Brazil) titanium implants were used, with dimensions of 3.75 x 13 mm (n=10). To obtain the specimens, self-curing acrylic resin (JET, São Paulo, SP, Brazil) was embedded in PVC tubes, 23 mm height and 17 mm in diameter. After polymerization, a 4 mm diameter by 17 mm height perforation was performed in the center of each specimen using a trephine drill (Neodent, Curitiba, PR, Brazil). The implants were then inserted into the cavities, positioned 1 mm above the resin base, and fixed with the same self-curing acrylic resin.

Comment [FE5]: Was a sample calculation carried out? How was the sample size decided?

To install the abutments in the implants, the II Plus universal trunnion, measuring 4.5 x 6.0 x 1.0 mm, was attached to the implant with an internal hexagon connection system, while the CM universal trunnion, measuring 4.5 x 6 x 0.8 mm, was screwed to the morse taper implant. Following the manufacturer's recommendation, with a 1.17 mm hexagonal wrench (ConexãoSistemas de Prótese, Arujá, São Paulo, Brazil), the torque applied to the abutments was 20 N.cm, given by a digital torque meter (TQ 8800, LT Lutron, Taipei, Taiwan). In order to ensure the maintenance of the preload and minimize the effect of the softening suffered on the screw threads, the abutments were re-torqued after 10 minutes with the same torque, following the protocol proposed by Dixon et al. (1995)[21]. To obtain the superstructures, a wax-up was performed using a castable cylinder (Neodent, Curitiba, PR, Brazil) as a base. A cobalt-chromium metal alloy (Starloy C, Dentsply, Petrópolis, RJ) was used and the manufacturer's specifications were followed in the casting process.

The superstructures were then cemented with calcium hydroxide-based temporary cement (Hydro C, Dentsply, Petrópolis, RJ, Brazil), using digital pressure for 1 minute, by a single operator.

The specimens were attached to a device connected to a servohydraulic universal testing machine (MTS, Minneapolis, MN, USA). The equipment was managed by TestStar II software (810 TeststarII, MTS, Minneapolis, MN, USA). Cyclic compressive loading in the range of 10 N to 100 N was applied perpendicular to the insertion axis of the implant components, as in the study described by Khraisat et al. (2002)[22], at a frequency of 25 Hz. A total of 212,600 cycles were performed to simulate one year of masticatory function[23].

Then, the superstructures were removed using Kelly. The prosthetic abutments were loosened with a 1.17 mm hexagonal wrench (ConexãoSistemas de Prótese, Arujá, SP, Brazil) coupled to a digital torque meter and the abutments' removal torque was measured in N.cm in order to evaluate the maintenance of the pre-established torque before the test.

The abutments and screws were analyzed by scanning electron microscopy (SEM) using an EVO MA15 microscope (ZEISS, Buenos Aires, Argentina). For this purpose, the components were cleaned with water and detergent in an ultrasonic cleaner (Unique, model Ultra Cleaner 750A, Indaiatuba, São Paulo, Brazil) for 10 minutes. Then they were immersed in 90°GL alcohol and dried Table 1 presents the descriptive analysis of the removal torque values, the length of the thread portion, and the distance of the thread pitches of the screws of the internal hexagon and morse taper connection implants.

Comment [FE6]: Add a statistical analysis methodology topic

Results and discussion

The data showed no significant difference between the values of removal torque presented by the internal hexagon and morse taper connections ($P = 0.609$), as shown in table 1. It was verified that the length of the screw thread portion of the internal hexagon connections was significantly greater than that presented by the morse taper connections ($P < 0.001$ - table 1), as illustrated in figures 1 and 2. Regarding the distance between screw pitches, no significant difference was observed between the screws of both types of connection evaluated ($P = 0.734$), as shown in figures 1 and 2.

Table 1. Mean (±SD) of the torque values of the length of the thread portion and the distances of the screw thread pitches of the internal hexagon and morse taper implants.

Connection type	Untorque (N.cm)	Length of thread portion (mm)	Thread pitch distances (μm)
Internal Hexagon	8.3 (1.5) a	3.36 (0.11) a	371.8 (15.0) a
Morse taper	7.4 (4.0) a	2.44 (0.07) b	374.2 (19.9) a

*Means followed by different lowercase letters indicate statistically significant difference between groups.

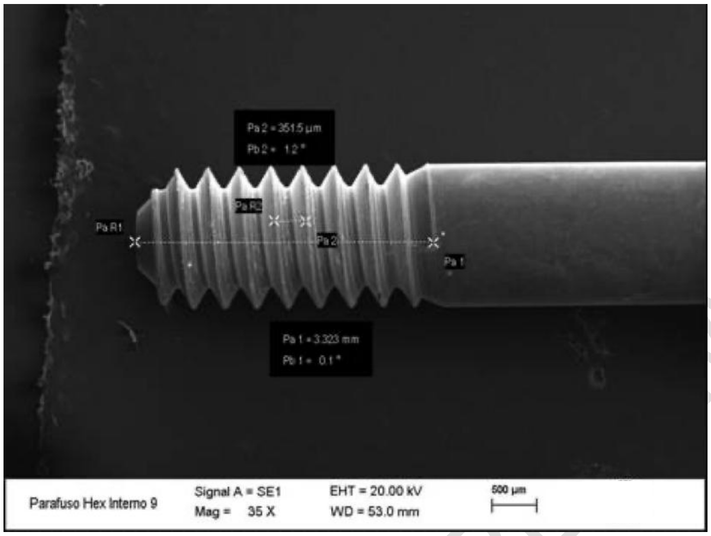

Figure 1. Scanning electron microscopy photomicrograph of an internal hexagon connection screw, revealing the length of the threaded portion and the distance between the thread pitches.

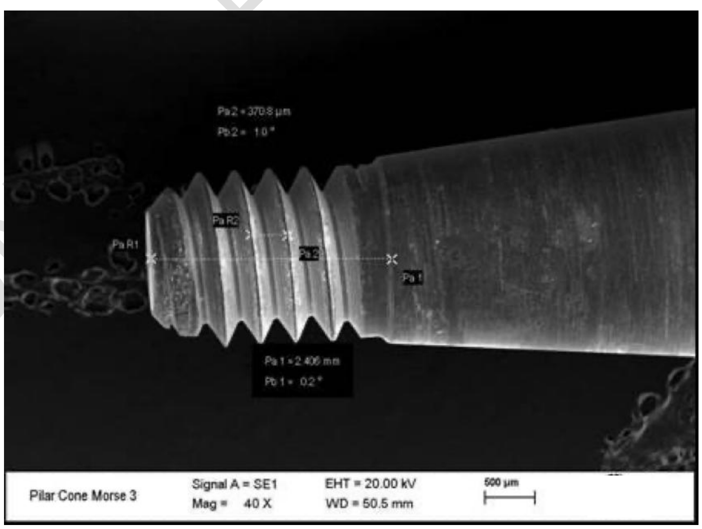

Figure 2. Scanning electron microscopy photomicrograph of a morse taper connection screw, revealing the length of the threaded portion and the distance between the thread pitches.

This study revealed that there was no statistically significant difference in the torque loss of internal hexagon and morse taper connection screws after simulating one year of masticatory function. However, some studies have shown superiority of the morse taper connection, mainly in relation to a lower torque loss of the screw after fatigue testing [11,12,14,15,24–27].

In some research the morse taper connection has shown an increase in the removal torque value of the prosthetic abutment screw after fatigue testing [19,28,29] which may imply greater clinical stability of the prosthesis over the implant, in the long term [14,29]. This finding may be due to the metal composition of the screw made of titanium alloys that tend to loosen less [10,18]. In this work the alloy composition of the components used for both the internal hexagon and the morse taper implants were also made of titanium alloys. However, when the implants of the internal hexagon system were subjected to occlusal loading, in a finite element study, the higher stress concentration was exhibit around the implant neck, and only a small stress concentration is concentrated in the prosthetic abutment screw. This simulation suggests that internal hexagon connections protect the prosthetic abutment screw from accumulated stress, exposing the implant walls to this stress[30].

In view of the findings of this study, both types of connection, morse taper and internal hexagon, behaved similarly concerning the removal torque in fatigue tests.

Due to the fact that screws that receive a lower or inadequate preload exhibit greater micromovement at the implant-abutment interface, retightening the screw to the same torque value ten minutes after the initial torque is recommended to ensure that the preload is maintained [11,31,32], and this exact protocol was used in this research.

To prevent screw loosening, in this research it was used prosthetic components of the same manufacturer of the implants, since prosthetic components from different manufacturers have different chemical and physical characteristics, which may lead to screw loosening[33,34].

It is known that the greater the variation in the angle of the intermediate to the implant, the greater the stress on the structures and bone tissue[35]. So, to evaluate the moment of the extreme force of the load on the analyzed structures, the direction of compressive loading on the specimens was perpendicular to the insertion axis of the implant components, according to the proposal described by Khraisat et al, (2002)[22]. However, even though the loading simulated an extreme condition, there was no fracture of the screws or components of the samples analyzed. However, some specimens from the morse taper group showed a small micromovement during the retorquing phase of the abutments. In fact, the variability in this group was three times higher compared to the internal hexagon. The significant difference observed between the length of the threads of the internal hexagon screws compared to the morse taper abutments ones, is probably due to the large number of threads on the internal hexagon screws. This may be because in the case of the internal hexagon connection implant, a two-piece component was used and in the morse taper connection implant only a single body prosthetic abutment was used. It should be noted, however, that although there may have been an effect of fatigue on the screw thread length and the distance of the screw threads of the prosthetic components, this evaluation would depend on the analysis of the samples also at a time prior to the fatigue test.

Regarding the distance of the screw thread pitch the data show that there was no deformation in the thread morphology of the screws and abutments analyzed, although a slight wear of the screw and prosthetic abutment material was observed.

In clinical practice, the success of a prosthetic rehabilitation from the patient's point of view depends on masticatory function and aesthetics, but another very important criterion in treatment planning would be the mechanical stability of the prosthesis. Therefore, torque loss of prosthetic component screws seems to be always linked to mechanical complications related to the prosthesis on implant[2,9,10,15]. In order to increase the predictability of rehabilitative procedures from the point of view of the effect of fatigue, this study showed that there was no difference in the removal torque value between the connections studied and revealed that there were no fractures of the components, even in the face of the significant difference between the length of the threads of the screws and abutments. However, further research to evaluate the maintenance of preload during fatigue tests would be interesting.

4. CONCLUSION

It was concluded that the portion of the threads of the screws of the internal hexagon connection was larger than that of the morse taper connection screws. The distance of the thread pitch and value of the removal torque under fatigue tests were similar in the screws of both connections.

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