ORIGINAL ARTICLE | OPEN ACCESS | PEER REVIEWED

Vertical removal force and torsional resistance of a screwless Morse taper implant connection

Arda Ozdiler, Enishan Ozcan, Omer Kutay, Gulbahar ISIK-OZKOL

ABSTRACT

Aim: The aim of this study was to measure the removal force and vertical tensile strength of a screwless Morse taper connection and compare it with screw retained connections. Methods: n order to measure the vertical tensile and torsional strength of the connection, a total of 12 Octo Implants (Tasarimmed, Istanbul, Turkey) 4 mm wide and 10 mm in length were used with a screwless Morse taper connection. Six repeated shots were applied to abutments for each standardized force: 300 grF, 500 grF, 800 grF, 1000 grF, 1400 grF, and 2500 grF. Measurements of vertical tensile strength and torsional strength were obtained four times for each group with a dynamometer and torque meter. Results: The results were analyzed using a 1-way ANOVA test. The intercept was found to be significantly different among the various strike forces for both vertical tensile strength and torsional strength (*p*<.0001). A greater increase in the torsional and vertical strength was seen for 1400 grF strikes and was consequently entitled as a break point. Conclusion: Screwless Morse taper connection is predicted to be an adequate resistant to vertical removal and torsional forces.

Keywords: Connection, Implant, Morse taper, Removal force, Torsional strength

How to cite this article

Ozdiler A, Ozcan E, Kutay O, ISIK-OZKOL G. Vertical removal force and torsional resistance of a screwless Morse taper implant connection. Edorium J Dent 2015;2:29–34.

Article ID: 100007D01AO2015

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doi:10.5348/D01-2015-7-OA-5

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Received: 06 May 2015
Accepted: 20 July 2015
Published: 16 September 2015

INTRODUCTION

A large number of successful dental implant cases have been reported since the osseointegration concept was first put forward by Branemark [1–3]. However, as a result of advances in the surface properties of implants, osseointegration has ceased to be the main criterion of success and has been replaced by criteria such as aesthetics and mechanical strength.

Implants are exposed to different types of forces in the oral environment that can lead to some technical complications. In order to reduce these problems, different manufacturers are working on various alternatives in different implant shapes, surface features, connection types, and superstructures. The aim of all these efforts in the restoration of missing teeth is to create more stable and resistant structures [4–8].

The two connection types that are used in dental implants are internal and external connections. Internal connections are divided into two groups; conventional screw retained internal connections and Morse taper internal connections (tapered, conical, self-locked, tapered, and tapered-screw retained, etc.). Manufacturers, in order to resolve the complications stemming from connection type, have recently modified internal connections. Tapered modifications are the most prevalent recent modifications, also known as Morse taper connections. Morse taper is a concept first put forward in 1890 by Stephan Morse and is currently used in many areas of industry. A Morse taper connection is when two co-jam on the tapered metal surfaces as a result of cold pressure welding formation. Implant-abutment interface in the internal connections is modified with this method. Some manufacturers use this modification on the neck of the interface with a conventional screw retained connection (ITI, Straumann, Basel, Switzerland - AstraTech, Dentsply, Mölndal, Sweden - Ankylos, Dentsply, Mannheim, Germany etc.). Other manufacturers prefer screwless Morse taper internal connections all along the interface. (Bicon, Boston , USA - MacSystem ,Cabon, Milan, Italy- Octo, Tasarimmed, Istanbul, Turkey)

Internal connections have a moment arm support point in the center of an implant, while external connections have the same point above the neck portion of an implant. This situation suggests that internal connections would be superior in resistance to mechanical complications when compared to external connections [9]. Results of Merz et al. study confirm the aforementioned opinion. Stresses all along the implant body were identified during the lateral loads. Found among the results, the internal conical connections had fewer stresses with a distribution in wider zones than the external connections [9]. Steinebrunner et al. examined the fatigue strength and fracture resistance of different connection types under dynamic loading. According to their results, the most resistant connection type is internal conical connection, regarding fatigue and fracture. This study also confirms the results of Merz et al. research [10].

Piermatti et al. in vitro study about screw loosening in internal and external connections resulted in a different opinion. According to this study, screw loosening is mostly associated with the screw design and quality of screw material rather than the connection type [11].

Screwless Morse taper connections are expected to eliminate screw related mechanical problems, most notably the lack of screws. Urdaneta et al. study about crown –implant ratio and its effects on mechanical strength with Bicon implants expresses that abutment loosening is mostly seen in the maxillary anterior region with the Morse taper connection design [12]. In the same study, abutment fractures were seen in 2 mm diameter abutments in the posterior region, but lack of fracture was reported with 3 mm diameter abutments. In Mangano et al. study, 1920 dental implants with a Morse taper connection were clinically followed-up for three years and 307 dental implants with a Morse taper connection were clinically followed-up for four year. Only two abutment loosening incidents were seen and no other complications were reported in the first study. In the second study, a low incidence of abutments loosening, 0.66%, were reported [13, 14]. In another study of Mangano et al., 80 dental implant Mac System (Mac System, Cabon, Milano, Italya) with a Morse taper connection were clinically followed-up; only 2 abutment fractures and 1 abutment loosening were reported [15].

In a study of Dibart et al., it has been reported that Bicon (Bicon Dental Implants, Boston, MA, USA) dental implants' pure Morse taper implant-abutment connection provides a hermetic closure and prevent the invasion of bacteria [16]. In a similar study by Assenza et al., internal conical connection and screw–retained connection were compared regarding bacterial leakage. According to the results, the conical implant–abutment connection had very low permeability to bacteria. High prevalence of bacterial penetration was also seen in screw-retained implant–abutment assemblies [17].

Despite all the advantages of Morse taper connection that are mentioned above, there is a limited knowledge regarding the differences in vertical and torsional strength of screwless Morse taper connections.

The aim of this study was to measure the torsional and vertical tensile strength of a screwless Morse taper connection and to compare it with screw retained connections. Results will show whether screwless Morse taper connections have an adequate vertical removal and torsional resistance.

MATERIALS AND METHODS

In order to measure the vertical removal force and torsional strength of the connection, a total of 12 Octo 4 mm wide and 10 mm length implants were used with a screwless Morse taper connection in this study (Tasarimmed, Istanbul, Turkey). All implants were buried in cubic containers full of acrylic resin (Simplex Rapid Kemdent Associated Dental Products Ltd, Wiltshire, UK). (Figure 1) Each abutment corresponds to the implants was buried in cylindrical containers full of acrylic resin. (Figure 2) A Sundoo brand dynamometer, torque meter, and test assembly (Wenzhou Sundoo Instruments Co., Ltd., Wenzhou, China) (Figure 3) were all used for measurements and adaptation of the implants and abutments to test assembly. Free surfaces of the acrylic blocks were integrated with metric 6 nuts (Mert Industrial materials Co., Ltd., Istanbul, Turkey) (Figure 4). To standardize the forces during the fixture of abutments into implants, a spring-loaded striker (pistol) was developed, and 6 repeated shots were applied to the abutments for each standardized force: 300 grF, 500 grF, 800 grF, 1000 grF, 1400 grF, and 2500 grF (Figure 5). In a similar study by Zielak et al. 1–5 times of repeated shots were performed and examined so we decided to exceed this number of shots in our study [18]. During insertion of dental implants in patients bone, implant drivers and driving torsions cause damage in tapered connection surfaces, in order to revive this damage in connection and avoid failures in connection, measurements of vertical removal force and torsional strength were done for four times in each sample with a dynamometer and torque meter.

RESULTS

The results (means) of vertical removal force and torsional strength between 300 grF–2500grF strikes are listed in Table 1. Despite overcoming the limits of the dynamometer (100 N) and torque meter (50 N/cm) with 2500 grF strikes, the connection remained stable and the highest values were seen (100 N for vertical removal force -50 N/cm for torsional strength). The results were statistically analyzed using a one-way ANOVA test. The intercept was found to be significantly different among the six different strike forces for both vertical removal and torsional strength (p<.0001). Linear progression of vertical removal force and torsional strength with six different strike forces is illustrated in (Figures 6–7). A greater increase in the linear progression was seen for 1400 grF strikes and is consequently entitled as a break point.

DISCUSSION

The aim of this study was to examine the vertical removal force and torsional strength of a Morse taper connection. According to the results of this study, if a vertical removal force greater than 59 N–100 N does not occur in the oral environment, the system is predicted to be adequately resistant to vertical forces. To be certain about the vertical removal strength, the maximum vertical tensile force that can occur in the oral environment must be known. Unfortunately, there are no such study on this subject.

Due to the torsional strength results, the system seems to be adequate regarding resistance to abutment loosening. Increased strike forces lead to a better torsional strength that may prevent abutment loosening caused by

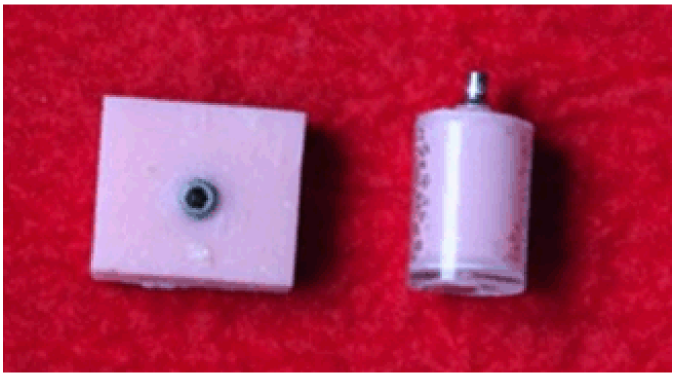

Figure 1: All implants were buried in cubic containers full of acrylic resin.

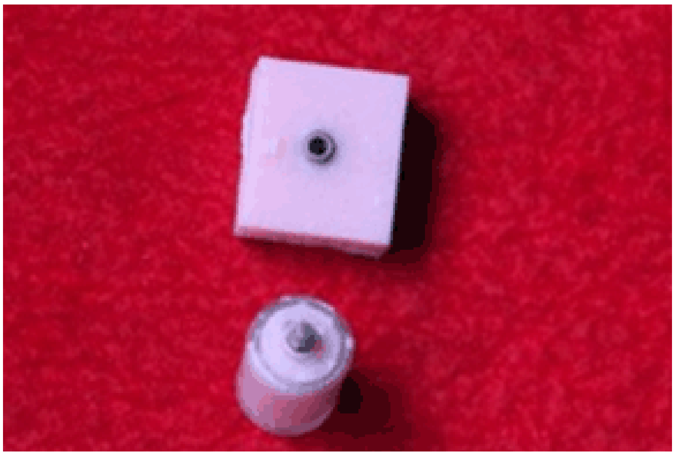

Figure 2: Implants and abutments were buried in cubic containers full of acrylic resin.

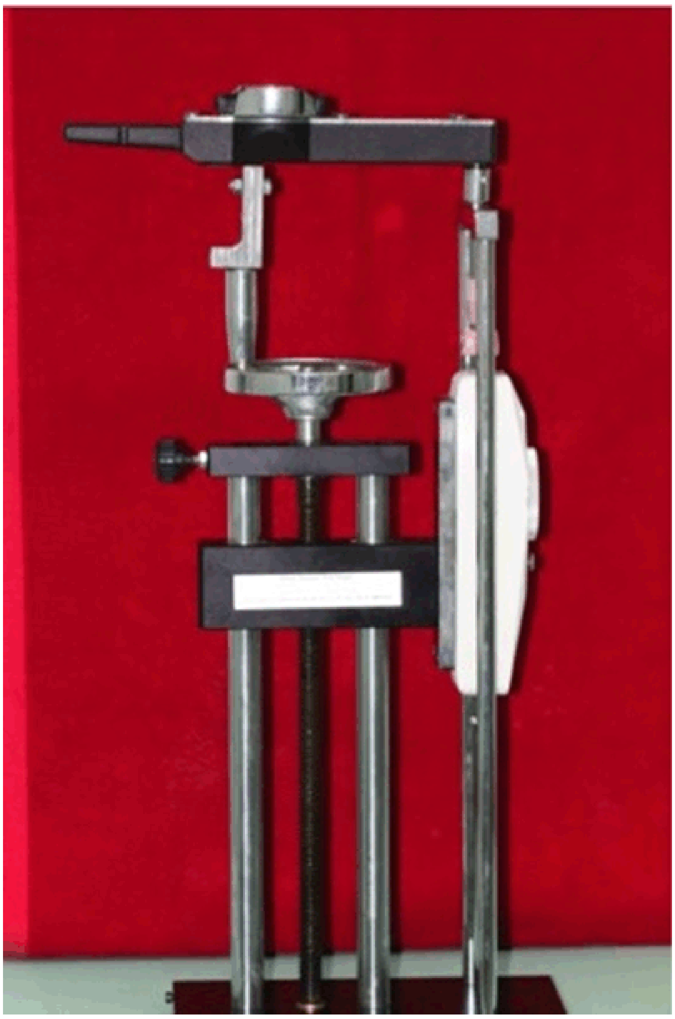

Figure 3: Test assembly, dynamometer and torque meter.

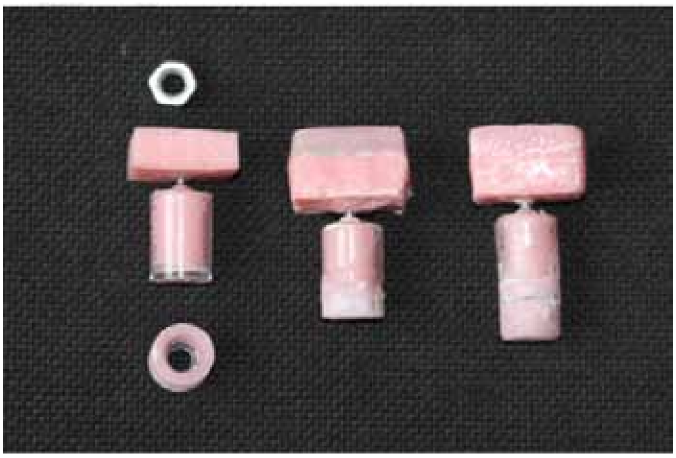

Figure 4: Acrylic blocks were integrated with metric 6 nuts.

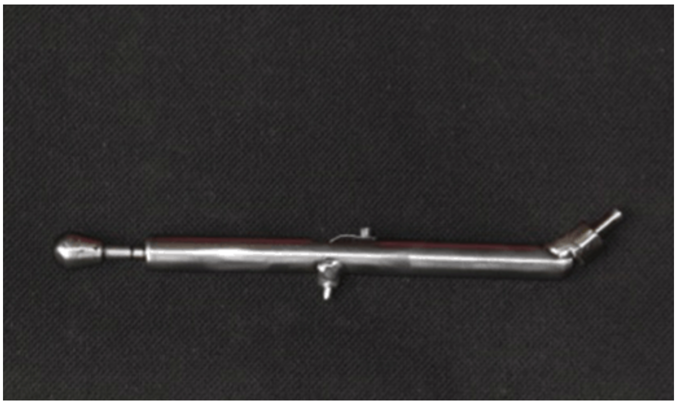

Figure 5: Spring-loaded striker (pistol).

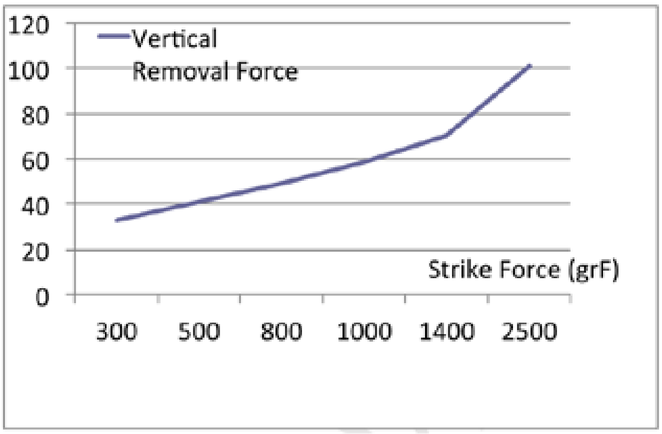

Figure 6: Lineer progression of vertical removal force within the increased strike forces

the axial forces that may occur in the oral environment. Strike forces 1000 grF and higher would be necessary for a sufficient torsional strength.

In a similar study, on screw retained Morse tapered implants by Weiss et al. different kinds of connections were used. Opening torque values were also measured after repeated closures [19]. Opening torque values of

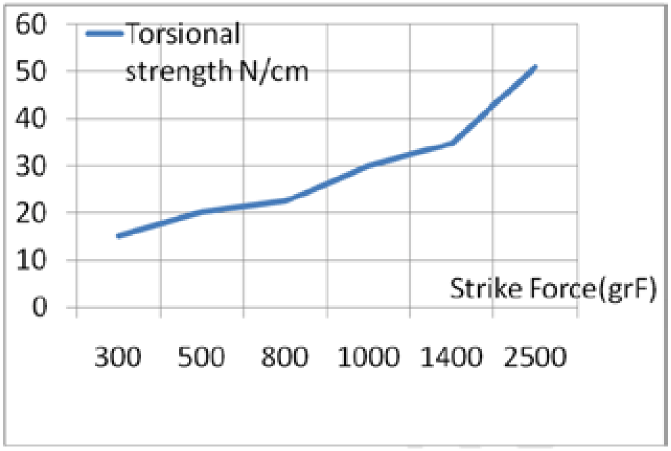

Figure 7: Lineer progression of torsional strength within the increased strike forces.

screw retained Morse taper ITI and Alpha-Bio connections were 19.5±0.7 and 19.8±1.2, respectively, after a 20N/cm standardized closing torque. A torque loss occurred in the connections during the repeated closure. Although Wiess et al. preferred to use 20 N/cm closing torques in their study, manufacturers recommend a maximum 35 N/cm closure torque for a rigid and safe connection. Closure torques higher than 35 N/cm are not recommended in order to not endanger the osseointegration. In our study, we reached the aforementioned value with 1400 grF strike force. Also, with strike forces higher than 1400 grF, torsional strength higher than 35 N/cm occurred. If these results are compared, pure Morse taper connection seems to have higher torsional strength without endangering the osseointegration.

In another similar Squier et al. study, both the removal torques of ITI implants conical connection and the effects of anodization on removal torques were examined [20]. Half of the 80 ITI solid screw implants were mated with solid abutments. The other half were mated with the synOcta (Straumann USA, Waltham, MA) internal positioning interface. According to the results, the highest removal torque values were seen in non-anodized synOcta Abutments (mean = 37.16 N/cm). In our study,

Table 1: Statistical differences between six different strikes in vertical removal force and torsional strength

Force (grF)	*n*	Vertical Removal ((N) Mean ± SD	Torsional strength (N/cm) Mean±SD
300	4	32.75 ± (1.25)	15.25 ± (0.9)
500	4	40.75 ± (1.7)	20.25 ± (0.9)
800	4	49 ± (0.8)	22.5 ± (0,5)
1000	4	58.75 ± (0.9)	30 ± (0.8)
1400	4	70 ± (0.8)	34.75 ± (0.5)
2500	4	≥ 100	≥ 50
One-way ANOVA		*p*<.0001	*p*<.0001

we reached the value of 50 N/cm with 2500 grF strike force. If the results are compared with our study, pure Morse taper connection of Octo implants seemed to be most successful regarding torsional strength within the 2500 grF strikes.

CONCLUSION

According to the results of this study, one can conclude that (i) screwless Morse taper connection is predicted to be adequate resistant to vertical removal forces, and (ii) screwless Morse taper connection has an adequate torsional strength like screw retained connections.

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Author Contributions

Arda Ozdiler – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Enishan Ozcan – Analysis and interpretation of data, Revising it critically for important intellectual content, Final approval of the version to be published
Omer Kutay – Analysis and interpretation of data, Revising it critically for important intellectual content, Final approval of the version to be published
Gulbahar ISIK-OZKOL – Analysis and interpretation of data, Revising it critically for important intellectual content, Final approval of the version to be published

Guarantor

The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

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