Comparative study of torque resistance and microgaps between a combined Octatorx-cone connection and an internal hexagon implant-abutment connection

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The success of dental implant treatment has been well documented. However, many key factors are involved in the success of dental implant treatment including, surface treatment of the dental implant, dental implant design, abutment design, and implant-abutment connections. One issue that might influence the success of dental implant treatment is early crestal bone loss. A meta-analysis study of marginal bone level changes around dental implants after 5 years in function by Laurell and Lundgren showed that the pooled mean marginal bone level change of 3 implant systems were in the range of 0.24 to 0.75 mm. They concluded that the documentation of marginal bone level change should be mandatory because it is a key factor for the long-term success of implant treatment. Oh et al reviewed the possible causes of early implant bone loss. They concluded that the possible causes of early implant bone loss include surgical trauma, occlusal overload, microgap, periimplantitis, biologic width, implant crest model, and implant-abutment connection.

Surgical trauma is one of the factors that may influence periimplant bone loss during the healing period. This trauma results from overheating during the drilling of the bone, from periosteal flap elevation, or from...
excessive pressure during implant placement. Because
the pattern of bone loss from surgical trauma is more
likely to be vertical than horizontal, that loss is similar to
the pattern of periimplant bone loss or saucierization.
Steigenga et al.7 studied dental implant design and its
relationship to long-term implant success. They also re-
ported that surgical trauma was an important contrib-
uting factor in the process of early implant bone loss.
Furthermore, they stated that occlusal overload could
result in the loss of marginal bone or osseointegration.
Occusal overload can be caused by improper implant
size or design, incorrect number of implants to support
the restoration, excessively cantilevered pontics, exces-
sive parafunctional forces, or improper restorations. A
loosened screw is frequently the first sign of implant
overload. Balancing and reducing occlusal contacts to
the implant support area and the shortening or elimin-
ation of cantilevered pontics can reduce the excessive stress to
the crestal bone. Oh et al.6 concluded that occlusal
overload was likely a contributing factor to early crestal
bone loss, but if traumatic occlusion is combined with
inflammation, marginal bone loss rapidly progresses.
A microgap is a space between an implant fixture
and an abutment surface. When the 2 components in a
2-piece implant are fitted together, microgaps are inevi-
table. Tsuge et al.8 stated that microgaps are a probable
origin of microbial contamination. Microbial leakage may
cause inflammation of periimplant tissue that might lead
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dental implant. However, indices, or rotation locks, are usually designed with a clearance fit to facilitate the connection of implant and abutment. The use of rotation locks always results in rotational movement between 2 adjacent corners of the key and keyway. The most frequent problems of the implant-abutment connection are micromovement of the connection, microgaps between implant and abutment, and breakage of the retaining screw. These lead to unsuccessful dental implant treatment.

The combined Octatorx-cone connection has been developed to overcome the weaknesses of the butt connection. This connection is a combination of the cone connection and special torx index. Normally, torx has been defined as a star-shaped “hexalobular” drive with 6 rounded points. It was designed to permit increased torque transferred from the driver to the bit compared with other drive systems. This torx is popular in the automotive and electronics industries because resistance to cam-out, extended bit life, and reduced operator fatigue minimizes the need to bear down on the drive tool to prevent cam-out as described in ISO 10664. The Octatorx is a modified torx with star-shaped “octalobules,” as shown in Figure 1. The advantages of the Octatorx are resistance to torsion, prevention of micromovement, and ease of placement of dental implants without a specific position index for the future prosthesis; for instance, the triangular index dental implant must be placed with the triangle tip buccally. When comparing the Octatorx with the internal hexagon connection, the contact of the hexagon is a spot connection while that of the torx is a surface connection, resulting in improved stress distribution and prevention of movement during function, especially from shear force.

The cone connection is the upper part of the implant-abutment connection. The cone has its own tapered angle of approximately 6 degrees. To create the surface connection between the implant and abutment, there is a 200-μm shoulder at the lower part of the keyhole of the dental implant. When the abutment and implant are connected with appropriate torque, the abutment is seated on the shoulder and establishes the surface connection.

The purpose of the study was to compare the torsion resistance and microgaps of an internal hexagon implant-abutment and a combined Octatorx-cone connection.

**MATERIAL AND METHODS**

Ten commercial dental implants with internal hexagon implant-abutment connections and 10 commercial dental implants with Octatorx implant-abutment connections with a diameter of 3.75 mm and a length of 10 mm were used for the test. Both dental implant systems have been certified by the Community of Europe (CE marking; CE0197 and CE0123). A straight abutment was attached to the implant with a retaining screw with 30 Ncm of torque (Torq Control; Anthogyr). Each implant-abutment connection was attached to a universal testing machine (55 MT2-E3; Instron Corp). The torsional rotation speed was 90 degrees per minute. The universal testing machine was run until the connection failed. The torsional resistance was measured in Ncm. Statistical analysis using descriptive analysis and an unpaired t test (α=.05) was performed with software (SPSS v17.0; IBM Corp).

Ten implants of each connection type, internal hexagon connection and Octatorx-cone connection, were used for the microgap measurement. Each experimental implant was fixed perpendicularly in autopolymerized acrylic resin with its upper part exposed. Then a straight abutment was attached to the implant with a retaining screw with 30 Ncm of torque (Torq Control; Anthogyr). After that, the upper part of the implant with the abutment attached by the retaining screw was embedded in an acrylic resin block (2×2×2 cm). The resin blocks were longitudinally sectioned through the middle of the implant-abutment with a slow cutting instrument (IsoMet low speed saw, 11-1280-160; Buehler). Twenty specimens of each type of connection were tested. Then 6 measurements of microgaps of each specimen (3 on...
upper right area and 3 on upper left area as shown in Figure 2) were selected from 20 measurements (10 measurements from each side). Each measurement was performed under a scanning electron microscope (JSM-5600; JEOL) at ×2000. Because the results were not normally distributed, the mean microgap of each implant was determined, and the median value of each type of connection was reported and compared between groups with nonparametric Mann Whitney U tests (α=.05).

RESULTS

The average maximum torque of the Octatorx (203.6 ±17.4 Ncm) was significantly higher (P<.05) than that of the internal hexagon (146.4 ±16.1 Ncm).

Two specimens of internal hexagon and 4 specimens of Octatorx were excluded from the study because the specimens were not in the appropriate position after the cutting procedure. Then 108 (9 internal hexagon implants, Figure 3A) and 96 (8 Octatorx implants, Figure 3B) measurements were obtained. The median microgap of Octatorx was 1.19 μm, whereas that of the internal hexagon was 3.80 μm. A significant difference between groups was found and is presented in Figure 4 (P=.001).

DISCUSSION

The technical factors influencing the success of dental implant treatment are implant fixture design, surface modification, abutment design, and the implant fixture-abutment connection. The success criteria of dental implant treatment have been established. The most important success or survival criterion for dental implant treatment is the functioning of the dental implant in the oral cavity, especially for mastication despite the existence of bone loss during the functional period.

There are 2 main causes of failure of dental implant treatment: the loss of osseointegration, which leads to the loss of the dental implant and prosthesis, and the failure of dental implant components, including the breakage of the dental implant itself or the failure of the connection between the dental implant and abutment. The bone loss around dental implants has been considered as periimplantitis and crestal bone loss during dental implant function in the oral cavity. The crestal bone loss always occurs in the first year after prosthesis loading. Albrektsson et al and Smith and Zarb have proposed criteria for implant success, including that crestal bone loss occurring during the first year should be less than 2 mm and less than 0.2 mm annually. Actual periimplantitis leads to critical bone loss around the dental implant and failure of osseointegration. A literature review by Oh et al reported that the reformation of biologic width around dental implants, microgaps if placed at or below the bone crest, occlusal overload, and implant crest module may be the most likely causes of early implant bone loss.

Thus, the connection between the implant and abutment plays an important role in crestal bone loss around dental implants. Until now, the precise causes of this crestal bone loss have not been proved. However, Zipprich...
and tested following the standard testing procedure for a cone connection was machined to prevent micromovement. The combined connection of a mandatory index and a cone connection has been introduced and used in implant dentistry. The Octatorx is a newly developed connection with the main purposes of reducing the microgap and micromovement and of providing an appropriate situation for the reformation of biologic width, so called platform switching.

The connection described in this study was designed to prevent crestal bone loss around dental implants and to prevent micromovement. The combination of an octalobule mandatory index and a cone connection was machined and tested following the standard testing procedure for dental implants with ISO 10451. The results show that the torsion resistance was strengthened up to 30% when compared with the internal hexagonal index connection ($P < 0.05$), and the microgap decreased significantly when compared with the internal hexagonal connection ($P < 0.05$). Zipprich et al suggested that the lobular connection design produces less micromovement than the polygonal design. The Octatorx design seems to have less micromovement than does the polygonal mandatory index. A finite element analysis study by Yamanishi et al showed that implants with a conical implant-abutment connection may effectively control occlusal overloading on the labial bone and abutment micromovement. However, further clinical study of implant-abutment connections must be performed to clarify the relevance of the relationship between implant-abutment connections and crestal bone loss around dental implants.

**CONCLUSIONS**

The Octatorx abutment connection has significantly better torsion strength and a smaller microgap than the internal hexagonal mandatory connection ($P < 0.05$). This connection may prevent the crestal bone loss around dental implants that occurs with polygonal and butt joint connections. However, a well-designed, randomized, clinical trial should be conducted to gather scientific evidence.

**REFERENCES**


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