IMPLANT-ABUTMENT CONNECTIONS ON SINGLE CROWNS: A SYSTEMATIC REVIEW

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SUMMARY
Different implant-abutment connections have been developed in the effort of reducing mechanical and biological failure. The most frequent complications are screw loosening, abutment or implant fracture and marginal bone loss due to overload and bacterial micro-leakage. Ideal connection should work as a one-piece implant avoiding the formation of a micro-gap at the implant-abutment interface. Different *in vitro* and *in vivo* researches have been published to compare the implant-abutment connections actually available: external hexagon, internal hexagon and conical finding different amount of micro-gap, micro-leakage and marginal bone loss. The aim of this article is to describe, according to the most recent literature, different kind of fixture-abutment connections and their clinical and mechanical advantages or disadvantages.

Key words: abutment, fixture, implant, connection.

Introduction

Since the invention of the first implant system, a huge amount of other systems have been developed, some presenting similar characteristics to the original by Brånemark (1), other introducing original features. Every implant system differs from the others for the implant shape, materials, roughness, spirals, connection level, geometry and many other characteristics. Medical literature debated on all these different features in the effort of finding the most valuable, efficient and safe implant system not only in the short term but also for long follow-up. Regarding the connection geometry, Brånemark system suggested the external hexagon configuration to simplify implant insertion and later to provide an anti-rotational support for the prosthetic rehabilitation. The worst disadvantage is the mechanical behaviour when exposed to forces different from the axial. This would have led to a micro-movement and a mechanical instability at the fixture-abutment connection. Internal connections were developed to eliminate or eventually decrease the micro-movement at the connection level. Various studies investigated the mechanical and clinical implications of different kind of connections assuming that different implant-abutment connections might have different resistance to displacement and stress dissipation under functional load. It seems clear that micro-movement at the implant-abutment interface would have increased inflammation at connection level contributing to a marginal bone loss (2). Authors assumed that it is necessary to improve the mechanical properties of the connections that are actually available and that there is still lack of strong evidence of which of them behaviour better than the others clinically. The aim of this article is to describe, according to the most recent literature, the different kind of fixture-abutment connections and their clinical and mechanical advantages or disadvantages.

Materials and methods

An electronic research was conducted using the Medline database to find articles published in the last ten years regarding to implant-abutment connections. Only English articles were included in the review process. The following keywords were used: "implant-abutment connection" or "fixture-abutment connection" or "implant-abutment interface" or "external hexagon" or "internal hexagon" or "internal connection" or "conometric connection".

The general electronic research evidenced a total of 604 articles that were reduced to 80 abstracts of *in vitro* and in *vivo* studies regarding implant-abutment connections mechanical properties and clinical outcome on marginal bone loss and implant survival rate. The other articles were excluded because not pertinent with the argument. After analysing these 80 abstracts only 13 articles were selected for a full-text reading and were included in *in vitro* studies, RCT, prospective studies and retrospective cohort-studies.

External connection

External hexagon was the first connection system adopted in the modern implantology by Brånemark (3). First of all it was developed to simplify the mechanical matching between the abutment and the fixture. Later it was modified to provide an anti-rotational mechanism of the prosthetic abutment, useful in particular for partial restoration. External hexagon connections were extensively modified during years in matter of diameter, height and insertion torque.

This kind of connection presents some advantages. First of all, it is adequate for two-steps surgical procedure preferred by Brånemark, since it makes easier the second stage and the connection phase with the healing abutment. Secondly, external connection is easier to record in the impression and simplify the prosthetic phase for its adjustability and compatibility with different prosthetic solutions.

At the same time it presents different disadvantages that became more evident in partial or single implant rehabilitations. External hexagon, in fact, presents micro-movement under lateral load and this may create a micro-gap at the abutment-fixture interface (4). Different Authors investigated this condition and it is sufficiently clear that this micro-gap leads to micro-leakage and bacterial infiltration that may affect the long-term success of dental implants (5). Micro-gap is strictly related to the strength applied to the abutment so for these reason external hexagon connection should be avoided in those patients who present condition of functional overload (6) such as clenching or bruxism.

Internal connection

The internal hexagon connection was developed as an evolution of the external hexagon, trying to increase the load absorption in particular under a lateral force. This would have reduced mechanical and biological complications such as screw loosening, fracture and marginal bone loss. The greater depth of the connection in the fixture body allows a more homogeneous dissipation of the mechanical stress. It would have spread on the implant wall and consequently to the bone surrounding the entire implant and not only at the crestal level (7).

Different studies evaluated the mechanical and biological behaviour of internal hexagon *in vitro* and *in vivo*. *In vitro* evaluations showed an im-

proved mechanical resistance, higher de-torque values and less screw loosening compared to external connection under a cyclic load (8).
In vivo studies demonstrated an improved resistance at the abutment-fixture interface and a reduced, but even present, micro-gap under oblique forces. In a recent systematic review regarding micro-leakage, Authors evidenced that all the studies regarding different type of connections presented micro-leakage at the abutment-fixture interface. The amount of bacterial proliferation was significantly lower in the internal hexagon compared to external one. Moreover, micro-leakage was demonstrated of being associated not only with dynamic loading condition but also in static loading.
For these reasons, in order to obtain an excellent functional and aesthetic outcome, internal connections seem to guarantee an higher stability of soft and hard peri-implant tissue and more resistance to mechanical failure (9).

Conical connection

Conical connection is a particular kind of internal connection in which the abutment is fixed to the implant using the mechanical properties of a machine taper. A male member of conical shape fits into the female socket, which has a matching taper of equal angle. The connection works locking the two components for the mechanical friction between the wall of the abutment and the implant. Even though the mechanical friction was demonstrated to be strong enough, different implant companies decided to provide their connection of screw retention and anti-rotational systems. A large number of comparative studies investigated mechanical and biological behaviour of conical connections compared to traditional internal hexagon connections.
In vitro investigations showed that the major part of conical connection systems presents a micro-gap under static forces smaller than 10 µm (10) demonstrating a better fit of the abutment into the fixture but non eliminating it at all. Other Authors showed a minimal abutment movement and micro-gap formation under axial and oblique forces but a good resistance to torque loss and screw loosening (11). External and traditional internal connections resulted more frequently and markedly affected by micro-movements on cyclic load (12). Internal-cone implants have interface force transfer characteristics similar to a one-piece implant but an absolute bacterial seal cannot be achieved in a two-pieces implant system. For this reasons conical abutment should be preferred to the other connection systems in order to minimize bacterial micro-leakage (13).
Marginal bone loss was observed for all implant system and for different surgical procedures but conical abutment seems to have a better stability of peri-implant soft and hard tissue (14). It is still evident that the kind of implant-abutment connection is fundamental but cannot be the only factor that influences the mechanical and biological outcome of our rehabilitation (15). These could include mechanical properties such as the implant geometry and diameter, the connection screw length and thickness, the materials used for the fixture and the abutment and the contact area. Prosthetic factors such as the abutment shape or the kind of crown adopted, cemented or screwed but also biological and surgical factors such as one or two stages surgery and the bone quality of the patient and many others.

Conclusion

Different studies were performed with different approaches and they are often hard to compare. For this reason it is difficult to draw a conclusion on which abutment system behaviour better than the others.
External and internal hexagon connections have a comparable resistance to axial load along the

center of the implant. Mechanical stress increases when the force applied increase but the conical configuration can spread the load more homogeneously than the external hexagon but also the traditional internal connection along the fixture and the surrounding bone.
All the connection presented an amount of micro-gap and bacterial micro-leakage but conical connection systems seem to be behaviour better. Conical abutment seems to have less mechanical complications such as screw loosening or fracture and higher torque preservation.
In vivo studies presents comparable implant success and survival between conical and not conical connections but probably a lower marginal bone loss.
Further *in vivo* prospective studies are needed to increase the evidence of which connection offers the best performance on the long term remembering that is not the only factor that could affect our clinical results.

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Competing interests

None.

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Not required.

Patient permission

Not required.

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