

Implant Abutment Connection – A Review

Anuradha Nemane, Saloni Mistry, Surabhi Mahajan*

Department of Prosthodontics, G.D Pol Foundation Y.M.T Dental College and Hospital, Navi Mumbai, Maharashtra, India.

Abstract

The implant abutment connection plays a pivotal role in the long-term success of dental implants, influencing both mechanical stability and peri-implant tissue health. Since the introduction of the original two-stage implant system by Brånemark in 1965, abutment connection designs have evolved significantly to address challenges such as micro-movement, bacterial infiltration, and prosthetic complications. This article provides an overview of the historical development, classifications, and biomechanical considerations of implant-abutment connections, including external hex, internal hex, and conical (Morse taper) interfaces. The review also discusses the implications of connection design on clinical outcomes. Understanding these connections is essential for optimizing implant longevity and ensuring successful prosthetic rehabilitation.

Keywords: Implant-abutment connection, External hex, Internal hex, Morse taper connection, Biomechanical stability

INTRODUCTION

Implantology is a prosthetically driven specialty with a surgical component. At present, the global market presents a range of implant as well as prosthetic choices. This extensive variation is sophisticated and yet more complex, making it difficult for the clinician to choose between the available components. One such choice is related to the implant-abutment connection, which forms the soul of the prosthesis. The history of abutment connections in dental implants traces back to 1965, when Dr. Per-Ingvar Brånemark placed the first successful endosseous dental implant (Figure 1).^[1] Varied geometries have been introduced to counteract the major demerits of this, as well as the various external connections, such as the micro-gap formation and compromised stability of the abutment. The most notable are the cone screw, the cone hex, the internal octagonal, the internal hexagonal, the cylinder hex, the Morse taper, and spline connections.^[2]

CLASSIFICATION

Whether or not there exists an extension of a geometric figure above the body of the implant:^[2,3] (Figure 2)

- External Hex: There is an extension above the implant surface
- Internal Hex: The connection is recessed into the implant body.

Depending on the space between the connecting parts: (Figure 3)

- Slip fit: The implant-abutment connection has a passive fit between the two mating connections, e.g., external or internal hex
- Friction Fit: A connection feature where the mating components fit with friction rather than passivity, e.g., Morse taper and cone screw connection.

Depending on the angulation between the connecting parts: (Figure 4)

- Butt Joint: the connecting surfaces are at 90° to one another
- Bevel Joint: The connecting surfaces are at an angle internally or externally.

According to the geometrical configuration: (Figure 5)

- Octagonal
- Hexagonal
- Conical
- Trilobe
- Spline.

EXTERNAL IMPLANT ABUTMENT CONNECTION

The external hexagon was the first connection system (Figures 1 and 6) adopted in modern implantology by Brånemark in 1965.

Address for correspondence: Surabhi Mahajan,
Department of Prosthodontics, G.D Pol Foundation Y.M.T Dental College
and Hospital, Navi Mumbai, Maharashtra, India.
Email: surabhi9274@gmail.com

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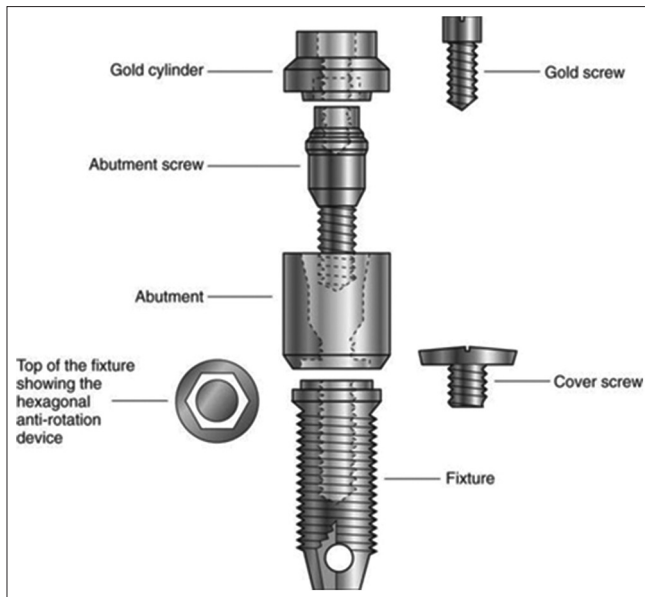


Figure 1: The original Brånemark implant design

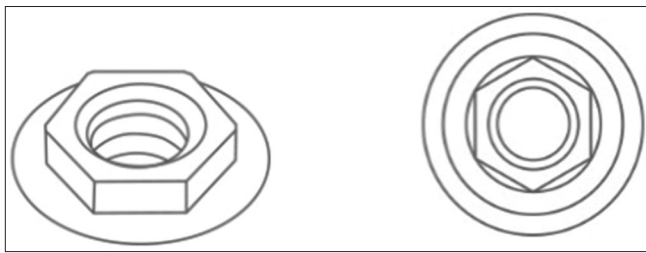


Figure 2: External and internal hex

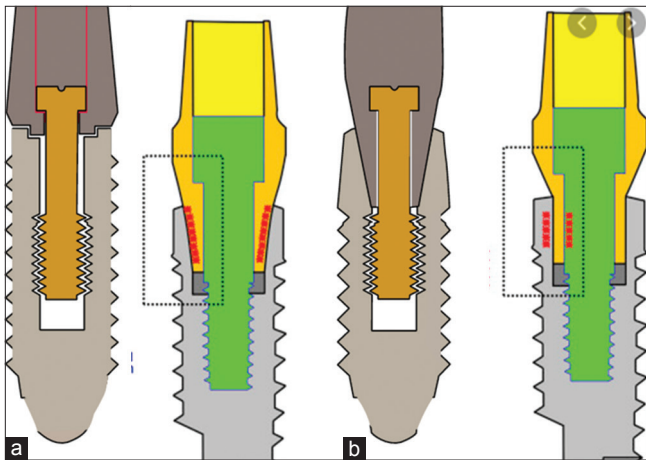


Figure 3: (a) Slip fit, (b) Friction fit

Advantages:

- Makes the second stage and the connection phase with the healing abutment easier
- Easier to record the impression and simplify the prosthetic phase for its adjustability and compatibility with different prosthetic solutions.

Disadvantages:

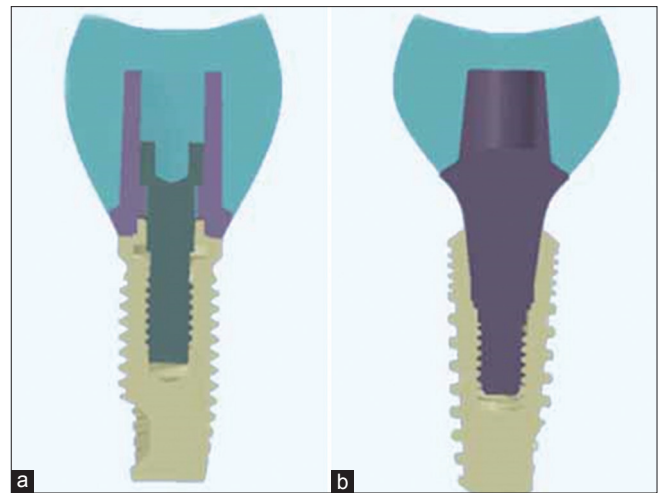


Figure 4: (a) Butt joint, (b) Bevel joint

- It presents micro-movement under lateral load, creating a micro-gap at the implant-abutment interface
- Limited screw engagement and a short fulcrum arm together allow for frequent screw loosening, resulting in an opening of the implant-abutment connection.

Modifications of the external hexagon:

1. The tapered hexagon
2. External octagon and
3. The spline dental implant.

TAPERED HEXAGON (FIGURE 7)

It was first introduced by Swede-Vent TL (Paragon Implant Co, Encino, CA). A 1.5° taper is incorporated into the hex flat, and a corresponding close-tolerance hexagonal abutment recess that is friction is fitted onto the hex.^[4]

Advantages:

- Reduced micromotion leads to reduced freedom of rotation between the implant and the abutment and thus reduced incidence of screw loosening
- Mating hexes interdigitate with frictional fit for added accuracy of the transfer procedure and increased stability in function. Thus offering a definite advantage as compared to the traditional external hexagon
- A notable modification involves the addition of microstops in the corners of the abutment hexagon that engage the corners of the implant hex (ZR Abutment, Implant Innovations Inc).

EXTERNAL OCTAGON

The external octagon was first marketed as a 1-piece narrow diameter (3.3 and 3.5 mm) implant (ITI Narrow Neck). It was designed to replace the mandibular anterior teeth. The tall, octagonal extension allowed for 45° rotation.^[2]

Advantages:

- Provides a greater number of positions to place the abutment over the implant.

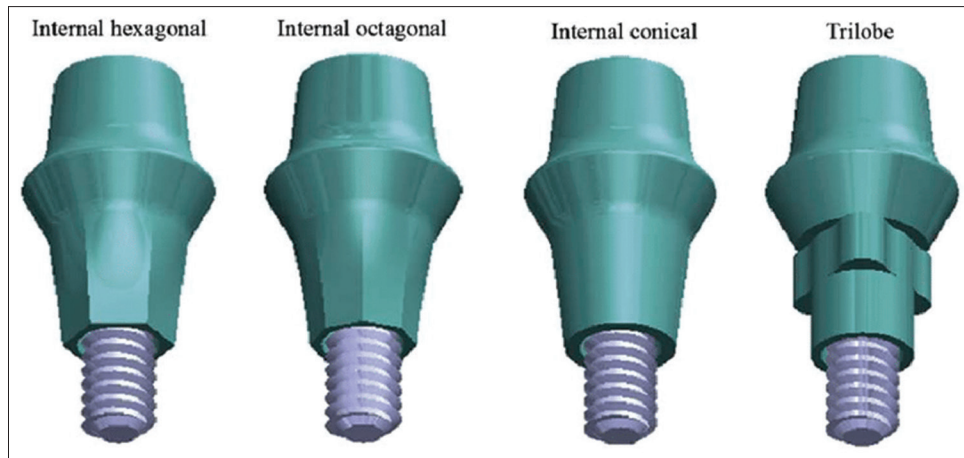


Figure 5: Internal hexagonal, internal octagonal, internal conical, and trilobe connection

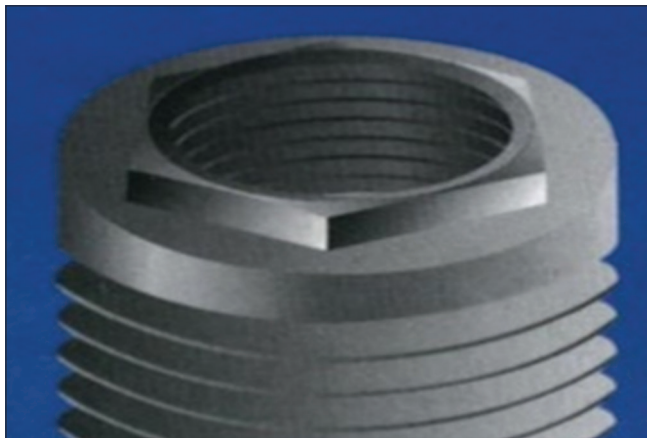


Figure 6: The standard external hex

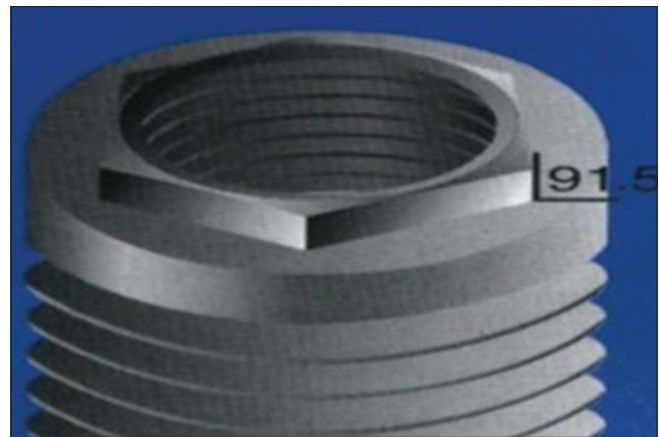


Figure 7: Tapered external hex

Disadvantages:

- The geometry of this connection represents a circle, offering very minimal resistance to rotation
- The design is not compatible with the use of angled abutments. Hence, it is not considered a very popular implant-abutment connection design.

SPLINE DENTAL IMPLANT

Developed by Calcitek (Calcitek, Carlsbad, CA) in 1992. Six spline teeth project from the implant body and fit into the grooves of the abutment between the projections from the corresponding abutment (Figure 8). The series of opposing parallel splines match integrally with the corresponding grooves of the opposite member. It is available in platform diameters of 4, 5, and 3.25 mm.^[5]

Advantages:

- The spline teeth matching integrally helps achieve excellent locational accuracy, and the fit between the implant and the abutment is a “snug fit”
- The 4- and 5-mm diameter implants are strong and mechanically stable and offer reduced incidence of screw loosening and rotational movement as compared to the traditional external hexagon.



Figure 8: Spline connection

Disadvantages:

- The 3.25 mm diameter implant is thinner, with small spines and a narrow platform, which results in a frail, vulnerable interface, and no clinical reports have been published on the stability of this interface
- Thus, though the 4- and 5-mm diameter spline dental implants have proven advantages over the traditional external hexagon, the 3.25 mm spline dental implant was not a very popular design.^[6]

PARADIGM SHIFT FROM EXTERNAL TO INTERNAL IMPLANT ABUTMENT CONNECTION

Internal connections were first introduced by Niznick in 1986. The goal of this design was to improve connection stability

through function and placement. The initial internal connection had a 1.7 mm deep hex below 0.5 mm wide, 45 bevel. The cover screw is held at the level with the top of the fixture at stage 1 surgery compared to the external hex, which is required to hold the cover screw slightly above the level of the fixture.^[7,8]

Advantages of internal hex:

- Distribution of lateral loading deep within the implant
- Long internal wall engagements create a stiff, unified body that resists joint opening
- Reduced vertical height platform for restorative components
- More platform-switching options
- A shielded abutment screws
- Less screw loosening
- Lower the restorative interface to the implant level esthetically. Thus, better esthetics
- Improved microbial seal
- Better joint strength.

Thus, internal connection implants can be divided into the following groups:

Passive fit/slip fit joint (space exists between mating components) (Table 1)

1. 6-point internal hex
 - Center pulse-core vent/screw vent
 - Friadent-Frialit-2
2. 12-point internal hex
 - 3i-osseotite certain
3. 3-point internal tripod
 - Alatech technologies, Camlog
 - Nobel biocare/Replace select.
4. Internal octagon
 - Omniloc, Sulzer Calcitek

Friction fit (no space exists between mating components)

Locking taper/Morse taper:

1. 8° taper (ITI Straumann, Avana, 3i TG, Ankylos)
2. 11° taper (Astra)
3. 1.5° tapered rounded channel (Bicon).

Six-point internal hexagon

This is the most common type of commercially available internal implant-abutment connection. It is manufactured by various companies, e.g., Zimmer Dental: Screw-Vent. It has an internal hexagonal-shaped anti-rotational feature (i.e., a six-sided geometric figure, a hexagon recessed into the body of the implant). The abutment can fit over the implant at every 60° rotation of the implant over the abutment but not at any other intermediate angle (Figure 9a).

An internal hexagonal connection (Frialit-2) is available commercially from Dentsply Friadent which is a unique internal design that extends 5 mm into the implant body. It combines the advantages of a cylindrical implant and an internal connection. The hexagonal connection is interposed between superior and inferior cylinders on the abutment

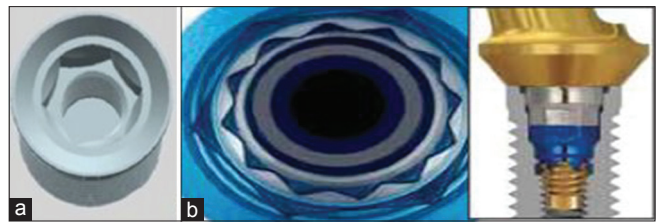


Figure 9: (a) 6-point internal hexagon. (b) 12-point internal hexagon

connection. The cylindrical connection provides lateral load resistance, resistance to joint opening, protection of the abutment screw, and high strength. When the joint does fail, only the abutment fails, and the implant remains intact (Hermetic Seal, Friadent).^[9]

Advantages:

- Distributes intraoral forces deep within the implant, improving the implant-abutment joint stability and providing easy seating
- Under a scanning electron microscope, it reveals a virtual “cold weld” between the two surfaces. Thus, provides a microbial seal, minimizes chances of screw loosening, provides lateral load resistance, resistance to joint opening, and protection of abutment screw
- Distribution of axial (are distributed to the step plateaus) as well as lateral loads (are dissipated to the enveloping surfaces) effectively
- Mechanical tests indicate good strength, minimal rotation, superior screw stability, and resistance to loosening, along with excellent machining tolerances
- Availability of a wide variety of abutments in 3.3-mm, 3.8-mm, 4.5-mm, 5.5-mm, and 6.5-mm platforms.

12-Point internal connection

The 12-point internal hexagonal design is available as an offset hexagonal design. In most systems, it is present along with the 6-point hexagon geometry (Figure 9b). The 12-point hexagon engages pre-angled abutments and provides 30° rotational positioning, e.g., Osseotite CERTAIN, 3i Implant Innovations, Inc. (Palm Beach Gardens, FL, USA).^[2]

Advantages:

- Provides the greatest freedom during abutment placement over the implant as it provides an opportunity to place the abutment on the implant for every 30° rotation, thus useful when using angled abutments
- Provides a greater opportunity to correct off-axis angulation of the abutment with respect to the implant.

3-point internal tripod

This type of implant-to-abutment connection represents a triangular internal geometry (Trichannel implant system). It is available in two variations: Cam tube and Cam log.

Cam Tube Connection was introduced by Nobel Biocare as the Replace Select tri-channel implant system. It is available in four diameters (3.5, 4.3, 5, and 6 mm) and is color-coded for ease of identification^[4] (Figure 10).

Advantages:

- The long tube insert offers excellent lateral stability, and the cam engagements provide convenient seating and indexing. Provides a precise fit of the abutment over the implant and has excellent lateral stability.

Disadvantages:

- Allows positioning of the abutment over the implant at only 120° of rotation thus making it not a very clinically preferred design.

The CAMLOG implant system by Altatec Biotechnologies, Irvine, CA, is an internal cylinder tripod implant-abutment connection. The length of the internal connection is 5.4 mm. It is claimed to have a “tube in tube effect.” Three symmetrically arranged grooves are located in the 1.9 mm deep cylindrical drill hole in the coronal region of the implant. This region leads apically to an upper thread. This is followed by a thinner and longish cylindrical threaded bore. The abutment screw of the two-piece abutment engages in this lower-thinner thread (Figure 11 a and b).

Advantages:

- The deep cam tube and tri-channel connections utilize three deep internal connecting engagements in a slip-fit joint



Figure 10: Nobel biocare internal tri-channel connection



Figure 11: (a) 3-point internal tripod CAMLOG connection, (b) Cylinder hex, cam tube, cam cylinder

- It has the deepest and strongest internal connection on the market, with a 5.4 mm deep internal connection
- Due to the stability of the joint, there is minimal screw loosening. The deep connection provides a much superior microbial seal.

Internal octagon

Internal octagon connection presents an 8-sided internal geometry, allowing for positioning of the abutment over the implant at every 45° rotation. e.g., Omniloc, Calcitek (Figure 12).

Disadvantages:

- Because of its thin walls, 0–6 mm length, and small diameter that presented a geometry profile similar to that of a circle, it offered minimal rotational and lateral resistance during function. Due to these disadvantages, the internal octagon connection is no longer marketed.

MORSE TAPER CONNECTION

The cone screw tapered or Morse taper implant-abutment connection concept includes a tapered projection from the implant abutment, which fits into a tapered recess in the implant. There is a friction fit and cold welding at the implant-abutment interface (Figure 13).^[10]

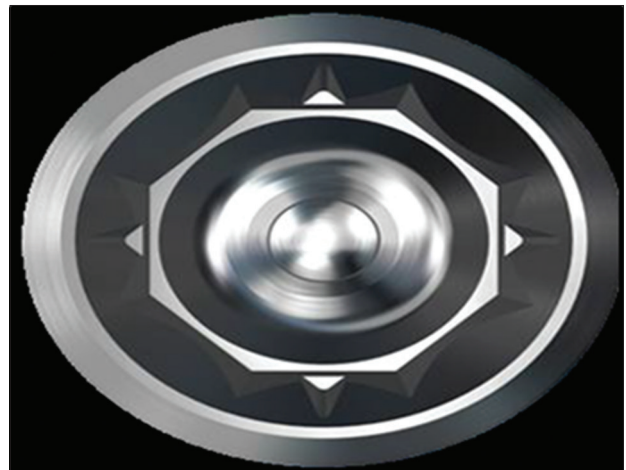


Figure 12: Internal octagon

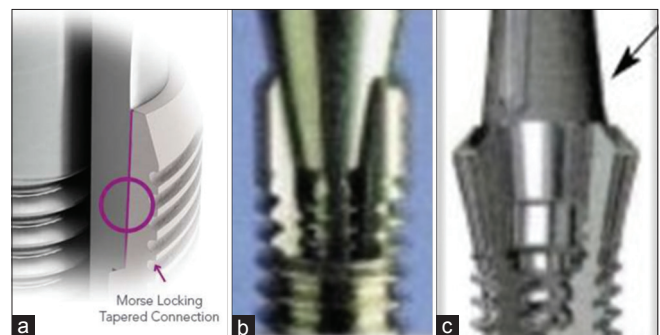


Figure 13: (a) Morse taper connection, (b). 11.5° Morse taper connection, (c) 8.5° Morse taper

Table 1: Abutment positioning with respect to various types of internal connections

S. No.	Type of connection	Commercially available implants	Abutment positioning over implant	Number of positions possible
1.	Internal hexagon	Centerpulse-core- vent/screw-vent Friadent-frialit-2	60°	6
2.	12-point hexagon	3i osseotite certain	30°	12
3.	3-point internal hexagon	Alatech technologies: camlog, nobel Biocare: replace select	120°	3

This implant-abutment connection depends on this friction fit for elimination for rotation at the implant-abutment interface and subsequent abutment screw loosening. The original concept of a true Morse taper exists at 2° and 4° and has a precise fit with unique self-locking characteristics without threads.^[11]

8° Morse taper connection

The cone screw tapered connection originated with the ITI group in Switzerland. The rationale was that a tapered connection would yield a mechanically stable, sound, and self-locking interface. An additional innovation first advocated with this implant design was the elimination of submergence during osseointegration, resulting in a 1-stage surgical protocol.^[12,13]

Although the connection is called a Morse taper, the mating angle between component parts is 8°. It is doubtful that the 8° connection would remain intact without its retaining screw component. However, the combination of the two stabilizing elements has resulted in a strong, stable, and predictable connection. Conical connections require precise machining and tolerances.^[2,14]

The joint configuration has no anti-rotational feature and depends entirely on the application of proper tightening torque and, most critically, the frictional resistance of its tapered walls. The long wall engagement does shield the screw and provides increased resistance to screw loosening. However, some clinical reports have reported screw loosening. A multicenter study of 174 implants reported that 8.7% of prosthetic screws and 3.7% of cone abutment screws were loose at 6 months.^[8] Another study, with a mean observation time of 3.5 years, reported loose screws at 9.1% and screw fractures and abutment complications at 1.5%.^[11]

Wiskott and Belser supplemented the Morse taper connection by introducing an internal hexagon in the middle of the Morse taper connection, thus allowing for the repositioning of the abutment and also the precise transfer of the implant position to the master cast. As a result, only one transfer system and one analog are required.

An implant introduced by Osteo-Ti, known as the Combi implant, has a mechanism for friction fit similar to that of the “octa” design and combines the features of an internal hexagonal implant and a Morse taper implant, allowing the abutment to be accurately transferred from the model to the patient’s mouth, and may eliminate the need for a laboratory

made abutment jig. Other manufacturers marketing 8° Morse taper implants are Avana, 3i TG, and Ankylos.^[15]

11.5° Morse taper connection

A similar cone screw connection with an 11° taper is available from Astra Tech. The abutment configuration is different in that it does not engage the external bevel on the implant and offers different length extensions with a 20° and 45° conical head. The original 11° cone design relied completely on screw and frictional resistance. This geometry has been modified to a 2-piece abutment with an anti-rotation hex feature at the end of the cone (ST, Astra Tech) for single-implant applications (Figure 13a).

1.5° Morse taper connection^[3]

A true Morse tapered implant interface connection is available (Bicon, Boston, MA) without any threaded component. The abutment has a 1- 2° tapered post that fits into a smooth mirror-image shaft within the implant. The abutment is seated with a sharp blow on the long axis of the implant, which generates a high clamping force between the abutment and the implant. The high friction force is the result of a relative slip between the two friction surfaces occurring at high contact pressure. This results in the breakdown of surface oxide layers, causing cold welding at the implant-abutment interface. It requires a dry, clean abutment post and implant shaft to secure the frictional resistance fit and provide optimal resistance to dislodgment. Without any indexing feature, it is not possible to transfer exact abutment locations with consistency and repeatability. Modification of straight and angled abutments has to be completed intraorally, which is difficult in complex multi-implant FPD applications. The manufacturer’s recommended method of removal for the intact abutment is to twist and turn with forceps. Retrieval of a fractured abutment post and retrofitting a new abutment may, therefore, prove challenging. Although the connection has demonstrated stability during function, it lacks flexibility from a restorative perspective.

Advantages:

A minimal abutment movement and micro-gap formation under axial and oblique forces. Good resistance to torque loss. Less incidence of screw loosening. Minimal bacterial microleakage.^[11,16]

CONCLUSION

The transition to internal connections has been gradual but profound. Industry-wise, it is very reasonable to conclude that

all major manufacturers that currently do not have an internal connection in their design options are working toward that end. An increase in the dimensions of the external hex, along with improved mating and tolerancing, modified load platforms, better screws, and higher torque application, have extended the life of the design.^[17] However, with the excellent variety of new interfaces available, it is unlikely that the external hex will survive very long into the new millennium. The internal connections that are available today are thus more stable, physically stronger, easier to restore, more amenable to excellent esthetics, and more user-friendly.

REFERENCES

1. Brånemark PI. Osseointegration and its experimental background. *J Prosthet Dent* 1983;50:399-410.
2. Muley N, Prithviraj DR, Gupta V. Evolution of external and internal implant to abutment connection. *Int J Oral Impl Clin Res* 2012;3:122-9.
3. Shah RM, Aras MA, Chitre V. Implant-abutment selection: A literature review. *Int J Oral Impl Clin Res* 2014;5:43-9.
4. Dittmer S, Dittmer MP, Kohorst P, Jendras M, Borchers L, Stiesch M. Effect of implant-abutment connection design on load bearing capacity and failure mode of implants. *J Prosthodont* 2011;20:510-6.
5. Barzilay I. Rotational accuracy of implant components for single-tooth, root-form implants. *Dent Impl Update* 1991;2:5-7.
6. Binon PP. The spline implant: Design, engineering, and evaluation. *Int J Prosthodont* 1996;9:419-33.
7. Misch CE. Contemporary implant dentistry. *Implant Dent*. 1999;8:90.
8. Lemos CAA, Verri FR, Bonfante EA, Santiago Júnior JF, Pellizzer EP. Comparison of external and internal implant-abutment connections for implant-supported prostheses: A systematic review and meta-analysis. *J Dent* 2018;70:14-22.
9. Shetty M, KP D, Shetty NH, Jaiman R. Implant abutment connection: Biomechanical perspectives. *J Health Allied Sci NU* 2014;4:47-53.
10. Harder S, Dimaczek B, Açil Y, Terheyden H, Freitag-Wolf S, Kern M. Molecular leakage at implant-abutment connection: *in vitro* investigation of tightness of internal conical implant-abutment connections against endotoxin penetration. *Clin Oral Investig* 2010;14:427-32.
11. Ceruso FM, Barnaba P, Mazzoleni S, Ottria L, Gargari M, Zuccon A, *et al.* Implant-abutment connections on single crowns: a systematic review. *Oral Impl (Rome)* 2017;10:349-53.
12. Levine RA, Wilson TG, Higginbottom F, Solnit GS, Saunders S, Schwarz M, *et al.* A multicenter retrospective analysis of the ITI implant system used for single tooth replacements. *Implant Dent* 1996;5:52.
13. Buser D, Weber HP, Bragger U, Balsiger C. Tissue integration of one-stage ITI implants: 3-year results of a longitudinal study with hollow-cylinder and hollow-screw implants. *Int J Oral Maxillofac Implants* 1991;6:405-12.
14. Merz BR, Hunenbart S, Belser UC. Mechanics of the implant-abutment connection: An 8-degree taper compared to a butt joint connection. *Int J Oral Maxillofac Implants* 2000;15:519-26.
15. Möllersten L, Lockowandt P, Lindén LÅ. Comparison of strength and failure mode of seven implant systems: An *in vitro* test. *J Prosthet Dent* 1997;78:582-91.
16. Saidin S, Abdul Kadir MR, Sulaiman E, Abu Kasim NH. Effects of different implant-abutment connections on micromotion and stress distribution: prediction of microgap formation. *J Dent* 2012;40:467-74.
17. Shafie HR. Clinical and laboratory manual of dental implant abutments. Ames (IA): John Wiley & Sons Inc; 2014.