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REVIEW ARTICLE

Implant-abutment Selection: A Literature Review

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ABSTRACT

Dental implantology has come a long way since its introduction into the realm of dentistry. A variety of implant abutments have been made available in the market in correspondence to various techniques and materials used. This puts the clinician in a dilemma to select a scientifically based appropriate abutment for his case. This paper thus aims to give a simple classification of the wide array of implant-abutment prototypes available in the market and an overview of each specific type for its clinical applicability.

Keywords: Classification, Abutment connection, Prosthesis retention, Abutment material.

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INTRODUCTION

The introduction of dental implants to the world of dentistry has successfully added to the restorative options for treating both completely and partially edentate patients, thereby restoring their masticatory ability and esthetics. Implant dentistry evolved over about five decades and along with it evolved the restorative techniques and components to meet the high demands of various challenging clinical scenarios. Currently, there are more than 80 manufacturers[1] of implants all over the world and each one has different series of components or variations to make it unique. This scenario puts the clinician in a dilemma of selecting an appropriate abutment to accomplish the case satisfactorily especially if the implant placement has been challenging or compromized.

Review of the literature reveals many articles that highlight the various implant configurations available. Also, the surgical as well as restorative techniques are very well documented in the literature. However, there is a lack of an in-depth review of the implant abutments—the classification, types and the clinical application of each specific type. This paper, thus, aims to aid the clinician in abutment selection procedure by reviewing and revisiting this critical component with regards to its connection with the implant, the type of material, retentive mechanism for the prosthesis and its fabrication method. Flow Chart 1 shows the classification for the implant abutments on the aforementioned basis.

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TYPE OF IMPLANT (ABUTMENT CONNECTION)

Implant-abutment interface may vary depending on whether the antirotational features are included or not. The implant-abutment interface determines joint strength, stability, and lateral and rotational stability.[2] Implants without antirotational features have flat surface and they usually require the attachment of one-piece abutments. Conventionally, these implants are indicated only in case of multiple units that are splinted together by joining the overlying crowns or bars, thus, preventing the abutment malrotation. They are, however not indicated for single-tooth restorations as the lack of an antirotational feature results in persistent abutment malrotation and eventual prosthesis loosening.[2]

Antirotational features incorporated in the design prevent undesirable movement of their overlying abutments. Various antirotational features in current use include the hexagonal connection, the octagonal connection, the tripod connection, the spline connection, and the Morse taper connection (Figs 1A to E).

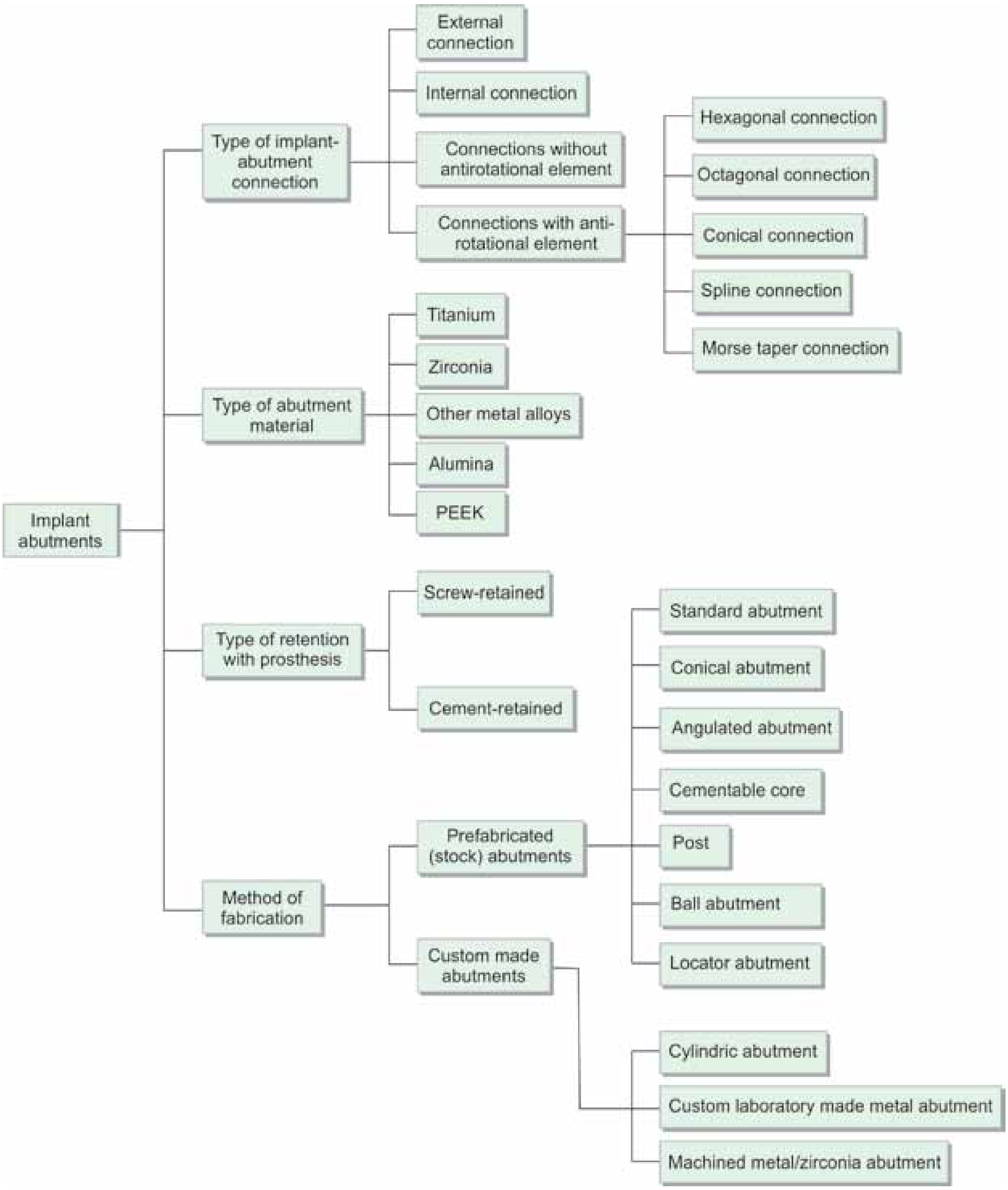
Implant abutment interface may be characterized as either slip-fit joint wherein a slight space exists between the mating parts or as friction fit joint wherein no space exists between the mating parts. Furthermore, the interface may even be characterized as either having butt joint, i.e. two right angled flat surfaces contacting each other or as angled surface that can be either internal or external.[3]

External Connection

The external connection has served well over the years and it has been incorporated in a number of systems. This design offers a great variety of restorative options due to the interchangeability of abutments among the manufacturers. Branemark's original implant-abutment interface was a 0.7 mm external hexagon which served the purpose of coupling and acted as a torque transfer device.[4]

This design had several drawbacks owing to limited height which makes it ineffective when excessive off axial load was applied.[5] Several complications like abutment

Flow Chart 1: Classification of implant abutments



screw loosening, fracture and micromotion at the interface associated with the Branemark's original external hexagon rendered it unsuitable for other applications like fixed partial dentures and single tooth replacements. Hence, a variety of its modifications are now available.[6]

Tapered External Hexagon

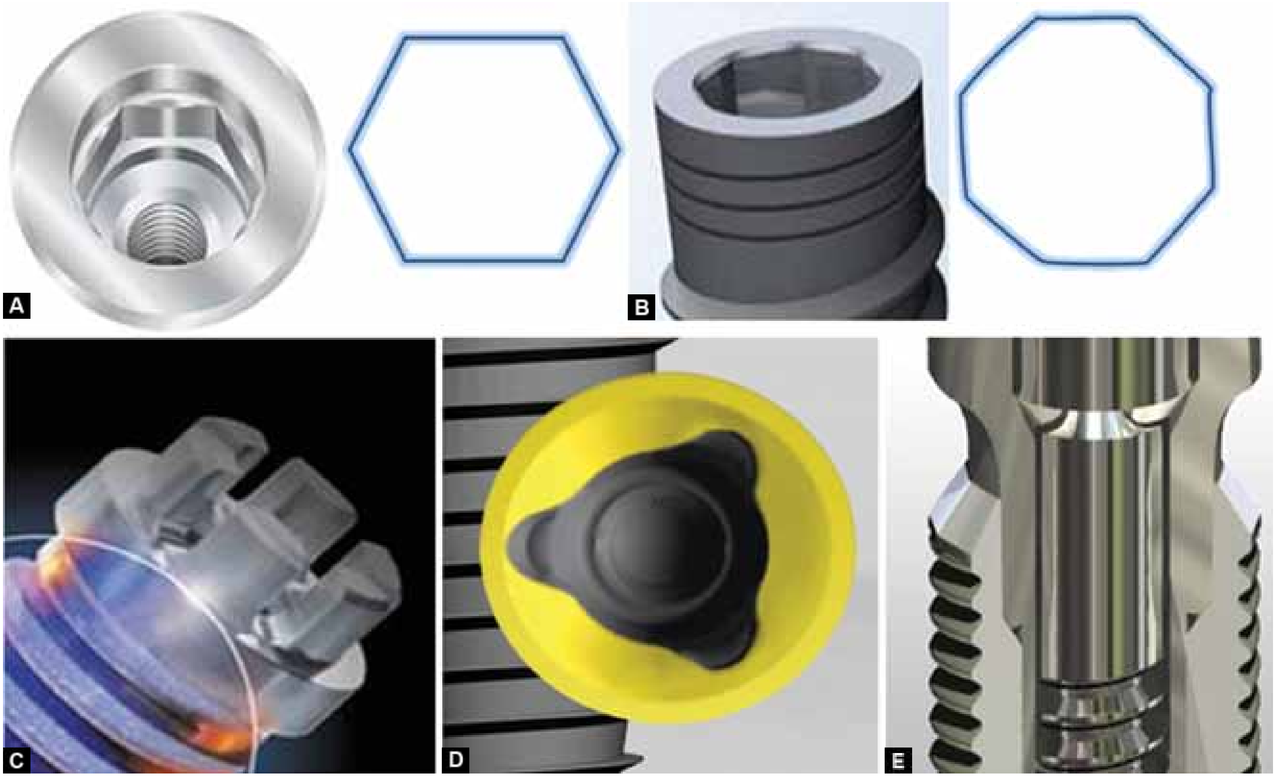
By creating a tapered interface, the mating hexes interdigitate with frictional fit for added accuracy in transfer procedure and provides increased stability in function.[7]

External Octagon

This is an eight-sided external implant abutment interface which allows for 45° rotation of the abutment. Since, the octagonal geometry resembles a circle, it offers very little rotational resistance and hence it is not very popular design.

Spline Connection

Splines are fin-to-groove antirotational configurations with a long and successful history in engineering. Developed



Figs 1A to E: Implant-abutment connections: (A) Hexagonal connection, (B) octagonal connection, (C) spline connection, (D) tripod connection and (E) Morse taper connection

by Calcitek, in the year 1992, consisting of six spline teeth which projects outward from the body of implant and fit into six corresponding grooves of the abutment.[8] There is a reduced incidence of screw loosening as well as minimal rotational movement as compared to the traditional external design.

Internal Connection

The goal of this design was to improve the connection stability throughout the function and placement and simplify the procedure. One of the first internal hex designs was introduced by Niznick in the year 1986.[7] The internal hexagon geometry offers several advantages. The internal hex design allows implant cover screw to be held in level with the top of the fixture at stage one surgery when compared to the external hex design, which is required to hold the cover screw that seat slightly above the level of the fixture.

Six-point Internal Hexagon

It is the most common type of connection that is commercially available. Due to hexagonal geometry, abutment can fit over the implant fixture at every 60° angulation—thus allowing six different positions. This design has proved to distribute forces deep within the implant effectively and, hence, improves the joint stability.[7]

Twelve-point Hexagon

The 12-point hexagon design is also marketed by several manufacturers since it allows for more options for abutment placement over the fixture. It allows placing the abutment on implant for every 30° angulation. A study conducted by Tang et al showed that 12-point double hexagon connection had better stress distribution and produced smaller displacement compared to other designs.[9]

Three-point Internal Tripod

This connection represents triangular internal geometry with trichannel design. Major disadvantage of this design is that it allows for positioning of the abutment on fixture only at every 120°. Hence, it is not a very preferred design because of limited options of placement.

Internal Octagon

This connection represents an eight-sided internal geometry and allows for positioning of abutment at every 45°. Because of geometric similarity to a circle, it offers minimal rotational and lateral resistance during the function.[4]

Morse Taper

It is a tapered projection from implant abutment that fits into a corresponding tapered recess in the implant, as proposed by Sutter et al leading to the friction fit and cold welding at the interface.[10] The taper interface prevents abutment tilting by resisting lateral loading.

8 Degree

It was first utilized by ITI group in Switzerland. The rationale for this design is that a tapered connection would yield a mechanically stable, sound and self-locking interface. To allow for rotation of abutment over implant fixture at different angles, Wiskot and Belser supplemented the original morse connection by addition of an internal hexagon in midst of the Morse taper connection.

11.5 Degree

Marketed by Astratech, this abutment consists of a conical seal design that seals off the connection and decreases the micromovement and microleakage at the implant-abutment interface.

1.5 Degree

Introduced by Bicon implants, it is a true Morse taper design with angle of taper 1.5°.

A systematic review concluded that the incidence of loosening of abutment screws was the most frequently occurring technical complication. More loose screws were reported for externally connected implant systems.[11] A FEA analysis also concluded that in general the magnitude of the stress produced by the internal hex implant system is lower than that of the external hex system.[12]

ABUTMENT MATERIALS

Titanium

Titanium is very well known for its near ideal implant properties. It has excellent biocompatibility[13] used for custom made abutments as well as prefabricated abutments. Previously, it did not provide an effective bond to porcelain with sufficient predictability, but newer technologies have made it possible; so, titanium is now a more preferred material for abutment.

Zirconia

Zirconia is increasingly being used as an implant-abutment material because it is denser and significantly stronger than alumina.[14] Thus, zirconia abutment does not show a catastrophic failure like those of alumina. Zirconium dioxide is a densely sintered ceramic mainly made up of very fine particles of ZrO_2 and Y_2O_3[15] and is generally used with computer-aided design/computer-assisted manufacturer (CAD/CAM). Zirconia is the abutment material of choice for all anterior restorations especially in those cases that demand an esthetic appeal. However, there is a tendency for chipping of the veneering porcelain which seems to be more significant for opposing restorations supported by implants. This can overcome by use of lithium disilicate pressed ceramic materials.[16]

OTHER METAL ALLOYS

Several alternatives were introduced for the fabrication of abutments, like gold alloy, stainless steel, nickel chromium and cobalt chromium alloys.[17] The abutments may develop galvanic action because of dissimilar metals that has the ability to affect electrochemical corrosion, oxidation and pain triggering.[1] Because of exorbitant gold price and advancements in CAD and 3D manufacturing, the paradigm now, has shifted toward the nonprecious alternatives. These are not ideal implant materials; furthermore, a cast object can never have the desired surface configuration required for seating onto the implant fixture. Even if gold has been used for this purpose, the casting and subsequent procedures will adversely affect the fitting surface. Cast restorations that are screw-retained are still in use, especially in cases where implant head is more superficial than intended-maintaining the biological width or when there is a limited amount of interocclusal space. But, the tissues around cast abutments made of nonprecious metal alloys are never as healthy as they are around other more biocompatible materials. Thus, these abutments should not be used where the implants are short and deeply placed to avoid peri-implant tissue inflammation.

Alumina

All ceramic abutments were introduced in 1993 as an alternative to titanium abutment to meet the high esthetic demands. Reports have suggested a high incidence of fractures of these abutments due to low fracture resistance of this material[18] and, hence, have been curbed as a desired abutment material.

Polyetheretherketone

Polyetheretherketone (PEEK) temporary abutments have been recently introduced for making implant-supported provisional crowns. It is a synthetic polymer with high biomechanical strength and inert chemical properties, which make it attractive for use in medical applications. Not much literature is available on the durability of these abutments. But, a research study states the fracture strength of the PEEK abutments similar to that of titanium abutments.[19]

RETENTION WITH PROSTHESIS

There has been a long standing debate between a screw-retained and a cement-retained prosthesis. A thorough understanding of their mechanism will help the clinician in selecting the ideal prosthesis for each clinical case while promoting its final esthetic outcomes. With the evolving technology and knowledge, an update of the current trends is also necessary. Table 1 gives an overview of their comparative evaluation for the purpose of clinical applicability; whereas Tables 2 and 3 enumerate the advantage and disadvantages of both the modalities.[20]

METHOD OF FABRICATION OF ABUTMENT

Alike abutments from different manufacturers may have slight variation, but most of the time they are nearly identical and can be placed in one of the two categories depending upon the type of restoration. Implant level restoration (2 tier system in which abutment is a part of the prosthesis) or abutment level restoration (3 tier system in which abutment is placed over implant and prosthesis placed over abutment).[21]

Moreover, the abutments may be machine made, prepared as needed (if any) and torqued atop the implant, typically called as prefabricated (stock) abutments or may be made in the laboratory individually for each case typically called as custom-made abutments.

Table 1: Overview of comparative evaluation of screw-retained and cement-retained restorations

Objective parameters	*Screw-retained*	*Cement retained*
Esthetics	Ideal implant positioning is needed	Universal because of no screw access holes
Retrieval	Possible	Possible but unpredictable
Retention	Possible even if less than 4 mm of height	Minimum 4 mm abutment height required
Occlusion	Might interfere in occlusion	Can be controlled in precise way because of no screw access holes
Complications	Susceptible to porcelain fracture, screw loosening/ fractures	Susceptible to peri-implantitis because of possibility of excess cement
Accessibility	Difficult	Easy
Cost	Expensive	Relatively cheap. Primarily due to lesser accessories required
Provisionalization	Better tissue response	Easy fabrication; Excess cement poses problem

Table 2: Advantages and disadvantages of screw-retained restorations

Advantages	*Disadvantages*
• Retrieval is possible	• Ideal implant position required
• Can be used in limited interocclusal space	• Restorations should be passive
• Better tissue response	• Possible occlusal interference
	• Porcelain fractures
	• Screw loosening and fractures
	• Difficult access
	• Relatively expensive because of components

Table 3: Advantages and disadvantages of cement-retained restorations

Advantages	*Disadvantages*
• Flexible implant positioning	• Retrieval is unpredictable
• Occlusion controlled in a precise way	• Minimum 4 mm of abutment height needed
• Easy access	• Excess cement leads to peri-implantitis and poor tissue response
• Relatively less expensive	
• Easy provisionalization	

Prefabricated (Stock) Abutments

Standard Abutment

The use of standard abutment is usually limited to multiunit restoration, especially in nonesthetic zones. This is because the margin of the abutment remains supragingival and it is difficult to achieve a good emergence profile with this abutment. It allows easy maintenance and margins can be easily inspected.

Conical Abutment

Conical abutment, commercially known as EsthetiCone, can be used in esthetic areas for multiple as well as single unit restorations. This abutment also allows for a good emergence profile. But, the disadvantage of this type of abutment is that its collar height is uniform circumferentially and it does not follow the natural contour of the gingival margin. Thus, it can result in collapse of the interproximal gingiva and may lead to tissue entrapment.

Angulated Abutment

Angulated abutment is similar to conical abutment except that it allows for correction of angulation and positional discrepancy. This abutment is available in 15 to 35° angulations. The implant surface of the angulated abutment is 12-sided internally; this shape allows it to fit onto the hexed implant in 12 different ways to simplify the abutment positioning.

Cementable Core

Commercially, it is known as CeraOne system. Here, the prosthesis which is cemented onto the abutment is fabricated on a core made of either a gold alloy or a ceramic material. It is highly esthetic abutment indicated, especially for single tooth replacements. However, because it is a cementable system, its retrieval remains unpredictable.

Post Abutment

It is screwed onto an implant intraorally or on implant analog in a master cast and prepared similarly like a tooth in fixed prosthodontics. It is available in both one and two piece systems. Available in many shapes, one piece post, commercially is available as cement on crown (COC) and the two piece post as CerAdapt. CerAdapt allows for the preparation of ceramic post in the laboratory which is then secured to the implant with a gold screw. The preparation can be refined intraorally and then a crown is fabricated which is cemented onto the post.

Ball Abutment

It is a prefabricated abutment used for the retention of a tissue-supported overdenture. It is available in multiple heights for varying tissue collar. Ball abutments can be used with either O-ring attachments or nylon inserts. The use of later has several advantages of applicability in cases with greater divergence and varying retention over the O-ring attachments.

Locator Abutment

It is a prefabricated abutment available for securing the attachment of an implant-supported overdenture or even a partial denture. It is available in multiple heights for varying tissue levels along with nylon (male) attachments that are color-coded for variable retention and divergence.

Custom-made Abutments

Cylindric Abutment

Commercially known as UCLA, the cylindric abutment is the only implant level restoration available, where the restoration is fabricated directly to the implant. The implant surface for this type of abutment is available as either hexed or non-hexed, wherein the hex engages the hexagonal design of the implant to prevent malrotation—used for single unit restoration or as custom abutments. The non-hexed type offers less rotational resistance and is used for multiunit restorations. Cylindric abutment allows achieving desired emergence profile by starting restoration at the implant level.

Custom Abutment

These abutments allow for an individual emergence profile of the reconstruction directly by the abutment. Hence, the crown margin can be positioned a short distance below the soft tissue margin and it follows the contour of the gingival margin. Customized abutments can be fabricated by either copy-milling techniques or computer-aided design/computer-assisted manufacture (CAD/CAM) systems. For both procedures, a resin or wax cast of the desired abutment is designed on a master cast by the dental technician. This prospective abutment (proabutment) can be used as a guide to individually shape an ingot with a copy milling machine.

For CAD/CAM systems, the proabutment can be scanned and digitized, and the data are then sent to a central production facility via the internet.[22] Another possibility to customize abutments with CAD/CAM systems is to virtually design the desired abutment without previous fabrication of a proabutment.

CONCLUSION

A variety of abutment designs and material are available to the clinician for accomplishing his case satisfactorily. The decision on the choice of abutment is based on many factors of which the clinical situation and clinician's personal preference leads the selection procedure. This paper aims at giving an overview of the wide array of implant-abutment prototypes available in the market.

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