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Implant Abutment Design Dealing with Traditional and Modern Types of Implant Abutment Design with Each Advantages and Disadvantages

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ABSTRACT

Dental implant technology has evolved significantly since its inception. In line with the range of methods employed, implant abutments have been introduced to the market. These affect the dentist's mind and put them in a dilemma when choosing an appropriate abutment design for their cases. For this reason, this paper clarifies abbreviated examples of implant abutment designs that are to be handed in the market and provides an overview of their clinical application in dentistry of each type. Each type of abutment that will be discussed in this review has many advantages and may encourage its usage, while others have disadvantages that may restrict its usage in some cases, as revealed in this article. Brand new abutments have been shown in this review, and they have overcome the obstacles faced by the usage of traditional abutments. On the other hand, traditional abutment is still necessary in economic situations.

Keywords: Abutment Interfaces, Abutment Types, Prosthesis Retention

1 Introduction

IMPLANTS in dentistry are prosthesis devices made of alloplastic materials inserted in the tissue of the oral cavity beneath the mucosal, periosteal layer, or bone, which help in retaining and supporting both movable and fixed prostheses in dentistry [1]. With the advent of implants in dental dentistry, various restorative alternatives have been effectively introduced to restore the chewing ability and smile of both fully partly patients with missing teeth [2]. Great progress in implantology has been accomplished in the latest decades by enabling implant treatment today to be a treatment plan not only for partially or completely edentulous but also a solution to treat mono-edentulism [3]. The advantages of dental implants are the maintenance of alveolar bone, a better alternative to bridging job and the alternative to bridging job and the elimination of the need for tooth preparation, and the elimination of certain dental issues such as bad fitness, gum irritation, and nerve pain [4]. Dental implants also have many benefits over standard dentures and fixed bridges, as they look like a normal tooth because when dental implants are integrated within the bone, they avoid bone loss and gum recession that generally accompany bridges and dentures. Also, dental implants do not sacrifice the value of neighboring teeth, such as bridges [4]. Abutments efficiently assist in shaping the restorative portion of the implant's prosthesis. The abutment offers the final restoration with retention, support, stability, and optimum position [5]. Implant-supported prostheses can be

manufactured using various methods. Due to their biocompatibility and advanced mechanical characteristics, the premade abutments supplied by the implant manufacturing firms are recognized as brand new. Furthermore, they are progressively substituted with custom abutments perfectly designed using CAD/CAM methods since drawbacks of premade abutments like aesthetic defects, mechanical inadequacy arising from implant positioning, incorrect profile of emergence, and unhealthy areas created below angled abutments. Custom abutments have practical and aesthetic benefits in contrast with premade abutments currently reported [2].

2 Historical Background for the Types of Implant Abutments

In the past, a large amount of research has shown ideal rates of survival for Ti abutments, which are useful for anterior and posterior portions of dental arch [6]. Metal abutments, however, have certain constraints and disadvantages, mainly linked to the esthetic outcomes. Clinical trials revealed that Ti-abutments created a gray color reflected through gingiva in the implantation sites that affect the achievement of therapy, particularly for individuals with a high/gummy smile row [7]. Designed by using CAD/CAM methods because of obstacles of premade abutments like aesthetic faults, mechanical inadequacy arising from implant positioning, non-preferable development profile, and unhealthy areas created below angled abutments [2].

2.1 Classifications of Provisional Abutment

Provisional abutments are generally manufactured in a premade stock manner in that they are pre-constructed machines. To create the contours of the tooth and the gingiva. In particular, in the esthetic region, many of these abutments are altered to create tissue contours [5]. Provisional abutment types include:

- Abutment of impression (transfer copy): That part of the dental implant is useful in providing special interaction with an end-osseous fixture to the alveolar ridge and contiguous dentition or other tissue [1].
- Healing abutment: This aids in the regeneration or alteration of neighboring tissue for a restricted period [1].

2.2 Classification of Final Implant Abutments

Implant used in supporting prosthesis constructions may be retained on the screw, and cement maintained on the fixture of the implant [2]:

- Crown with screw-retained: Screw retained prosthesis gains its retention by the fastening screw. However, in order to prevent issues with breakage or untying screws, it is essential to twist screws as per the requirements of the manufacturer. Screws were either gold or titanium made [2]. The stability is provided by the friction force created between the implant's inner threads and the locking screw. If a titanium screw is used, both implants and screw threads will suffer slight damage, resulting in a phenomenon called galling when joining them together. Gold screws, however, have a lower friction ratio that allows them to tighten more efficiently than metal without galling impact. Small misfits can generate distortion that alters the connection of preload force [3]. The advantages of screw-retained prosthesis are that it has less than 4 mm distance away from the implant platform to the occlusal surface of the opposite teeth enough, screw-retained restorations can be predictably retrieved, temporary screw-retained restoration can be easily used to widen tissue around the implant incrementally until completely placed. It can also be used as an impression transfer coping pick-up form, as well as temporary screw-retained reconstruction. Disadvantages of screw retained prosthesis are the access hole of the screw was located in the crown's center where the main touches must be so that occlusal interactions around the entry canal are unstable, less esthetic than cement-retained prosthesis due to the presence of the access hole [4, 5].
- Cement retained crown: Many implant companies subsequently implemented cementable solutions to screw preservation. Since then, cement-retained prostheses have become the preferred restoration method for treating clients with implants [3]. The suitable abutment designs that are used with cement restoration prosthesis, which include many options such as a customized abutment that promotes the development of anatomical gingival morphology with a normal emergence profile [6], stocks supplied by profound subgingival gaps (particularly interproximal) must be prevented that may cause the removal of cement particles more complicated [7]. Even when using a custom abutment, it cannot be ensured that there is no remaining surplus cement(8). Advantages of the cement-retained crown [3, 9] are restorations retained in cement are more esthetic; this idea stems exclusively from the absence of a noticeable access hole for the screw, It also pointed out the significance of constructing competing contacts on the restoration itself as opposed to the locking fabric material for screw entry, no screw entry channels interrupt the continuity of the metal-ceramic bond and occlusal stresses can be uniform across the majority of the crown material. Furthermore, there are many disadvantages of cement-retained prostheses that must have sufficient sizes of the implant abutment (mainly the height) needed to retain the crown properly. Excessive bleeding and cement restoration in a clean situation are hard to handle for optimal soft

tissue health. The remaining cement in areas around the implant can lead to the colonization of bacteria and harm to soft and hard tissues. When cement-retained restoration abutment screws lighten, the crowns aren't always removed predictably and often involve cutting and removal of the crown [13].

- Shape memory: A new and better implant retention system was created to combine screw (retrievability) and cement benefits by removing the drawbacks of remaining cement. A shape memory sleeve, "Smileloc; Rodo Medical" is accepted by the abutment. The clearly engaged posture closes the crown over the implant. Firstly, the sleeve's internal flaps are contained within the abutment undercut while the crown is inserted into the sleeve as shown in Figure 2. The external flaps involve the copy undercuts linking the (sleeve-copy) to the mechanically interconnected system as shown in Figure 3 [18]. Producing immediate touch with the copy made from Ti was performed by using a microprocessor-controlled activator probe, which entered in lingual perforations. It needs only 15 seconds of heating, after which flaps of the sleeve transform from a state of engagement to disengagement with the aid of thumb pressing. In this abutment-sleeve interlocking scheme, unlike screws and cement in which crown removal needs to undergo strain, vectors' force mostly develops compressive stress at sleeves [18]. The shaped memory sleeve is composed of nitinol, a mixture of nickel and titanium. Nitinol was ideally made from 50 to 51% nickel. A slight change in the composition of the alloy leads to an immense alteration in the transition temperature of that alloy. Temperatures of transformation in nitinol may be managed somehow by ranging the austenite stage from *−20 °C to +110 °C *. The solid stage is another term for martensites' changing, which is considered the reversible process of nitinol. The austenitic stage is considered a memorable stage during the manufacturing process, which is controlled by heat tempering. After cooling, the austenitic stage is changed to martensite without any physical change in form. This design of such abutment takes advantage of the shape memory characteristics of nitinol, in which the sleeve is structurally distorted to a single form in temp of room, afterward regains its normal shape, unchanged structure when heated until the top, slightly cool austenite to form martensite, distorting the martensite, then heating to return to austenite, thus undistorted and normal shape will be returned which known as the effect of thermal shape memory. Keeping the normal "parent shape," the alloy should be caught in its place and warmed until reaching 500 °C as shown in Figure 1 [19, 20].

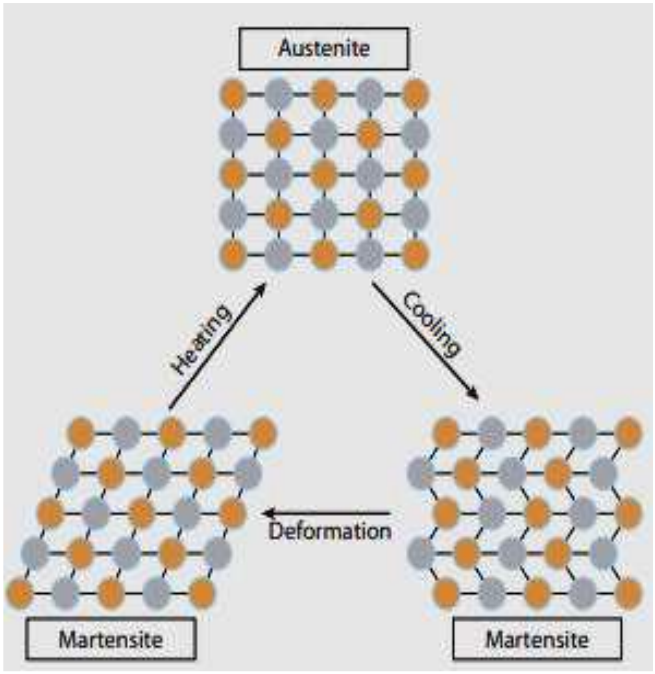

Fig. 1. Temperature of transformation [18].

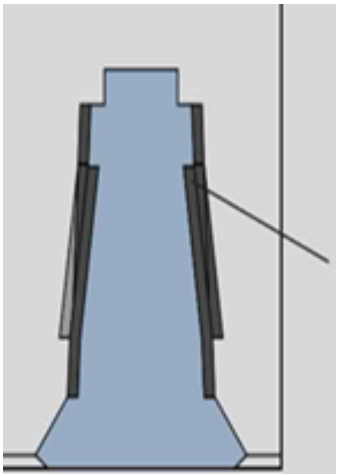

Fig. 2. Internal flaps locked on the abutment undercuts [18].

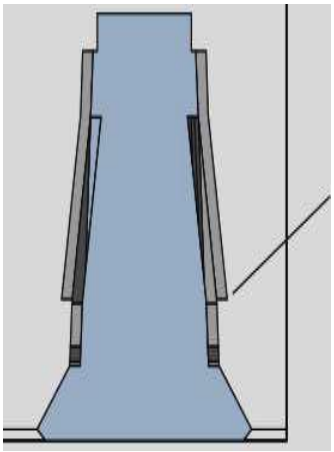

Fig. 3. External flaps engaged copy undercuts [18].

2.3 Prefabricated and Custom Abutment

The prefabricated implant abutment is made from distinct materials by the manufacturer and offers a link between fixture and reconstruction with a distinct width of its platform, depth, and gingival emergence profile [2]. The types of prefabricated implant abutments include:

- Stock abutment or standard abutment: Stock Abutments are generally mass-generated by manufacturers of implants and abutments. Not all of them are similar. Many of them were easy-to-be retainers used in prosthetic parts, while other types have advanced settings that attempt to replicate or approach forms that better suit a patient's clinical requirements with a particular setup of the implant location [21]. Two kinds of stock abutments, either straight or angled:
  a. Straight stock abutment: The first stock abutment may also be named "Simple stock abutment." Stems are essentially connected to the central part of the implant by cement or screw. Such abutment serves as a straightforward prosthesis retainer and relies on the implant's margin to interface with the prosthesis. This scheme relies on a margin that is not so crucial for esthetics and is often above the gingiva or with the level of gingiva [21]. Another collection of stock abutments should be connected to its holding implants, and it was designed to maintain the planned prosthetic part and act as a completing point to that prosthesis [21]. The designs of this collection of stock-type abutments are circumference round at the suggested margin, as this model is simpler to mill. They may have some flattened surfaces added to help with impression and laboratory processes. The clinician or laboratory technician may shape these abutments to remove undercuts that would impede the installation of the prosthesis. This modification of the abutment would be restricted as the abutment metal is not very dense. Modifications to the margin of this type of stock implant abutment frequently result in designs with a subgingival margin that resembles superficial chamfers or feather edges. These may actually lead the patient to remaining subgingival cement issues [21, 22].
  b. Angled stock abutment: Sometimes, anatomical limitations require the surgical positioning of implants at angles that are not ideal for prosthetic restoration. This is facilitated through the use of angulated implant abutments in carefully planned instances. A wide variety of pre-angled abutments are accessible at defined angles of divergence. Additionally, customized angled abutments can be cast into the profile needed to achieve an acceptable prosthesis result. The lateral occlusal forces may improve by using angled abutments during implant loading in the clinic [23]. Advantages of angulated implant abutment where there is an inappropriate jaw relation due to alveolar bone resorption or skeletal variance. Angulated abutments can try to compensate for with buccolingual and mesiodistal angulation of implants. An angulated abutment enables implants to be placed at appropriate amounts and bone qualities, which can be found in individuals with bone anatomy compromised [23]. Angulated abutment disadvantages increased stress and strain with increased abutment angulation and abutment screw failure [23].
- Multi-unit abutment: The angulations between implants might vary greatly due to the small profile of multi-unit abutments. The abutments may support up to 40 degrees of divergence between them after they are in situ, which aids in prosthetic repair. The doctor can position the implant cylinders to accommodate interocclusal space and mucosal tissue thickness because of the variable collar heights of multi-unit abutments. Multi-unit abutments' screw-retained features make it possible to have excellent retrievability and simple access for upcoming maintenance. By avoiding the sinus cavity and removing the necessity for grafting, they offer surgical flexibility by enabling the posterior implants to be slanted in accordance with the sinus mesial wall. The patient saves a significant amount of time and money as a result. Additionally, by tilting the implants, the anterior-posterior spread can be expanded, improving the prosthesis's biomechanical support. Working at the abutment level expedites the restoration procedure and enhances patient comfort. Multi-unit abutments are a way to create a consistent prosthetic platform for ease of reconstruction when multiple implant systems are used in the same arch [24].
- Ball implant abutment: Ball abutments have developed since the early 1960s for implant overdentures. Ball abutments with implant-supported overdentures were regarded as the easiest type of abutment for clinical implementation. However, it is also well known that O-rings gradually lose retention and have to be periodically substituted [25, 26].
- Locator abutment: A standard hinge resilient attachment is specified for use with a partial or complete overdenture that retains endo-osseous implants in whole or in a portion. These are the benefits of this design. Because the male component allows for a resilient prosthesis link without any loss of retention and has an auto-locating design that allows the patient to comfortably sit in the overdenture without requiring exact alignment of the attachment parts in a repeatable insertion trajectory, the locator abutment is characterized by a rotational pivoting design [10].

2.4 Newly Designed Custom Abutment

- Customized abutment casting (University of California Los Angeles): UCLA abutments were the start of the real custom abutment unit (new patient-specific). It even enabled the technician to wax up a distinctive abutment shape and begin the substitution tooth's emergence profile on a more subgingival area. This was a major benefit because it often led to better management of the form of the restorations. Some UCLA burnout models had the implant-abutment connection as part of the burnout design, specific for each implant system [27]. There are many problems with the UCLA premade base, which include investing, heating it to an elevated temperature, and then casting the abutment body's molten metal on it. This may skew the precision of its implant interphase; basic physical impressions, designs, pouring, and facing techniques are all factors in the prosthesis' error [27].
- Custom abutment for copy-milling: The copy milling technique uses the CAM and scanner. The abutment is usually contoured in waxes with a copy milling technique and then scanned to develop an abutment. It is time-consuming to create a wax replica of the temporary restoration and may not probably reproduce the transitional outlines of the temporary restoration [28, 29]. Copy-mill custom abutment procedures of manufacture include [30]:
  a. Make a temporary restoration directly to the endosseous implant that achieves clinician and employee requirements as shown in Figure 4.

Fig. 4. Provisional restoration [30].

  b. Take off the temporary fix from the implant. Place the interim restoration in a plaster impression after connecting it to an implant analog.
  c. Syringe the heavy-body vinyl polysiloxane around the temporary restoration from the implant interface to the incisal edge. Once the imprint material has polymerized, remove the temporary restoration and reinsert it into the implant as shown in Figure 5.

Fig. 5. Interim restorations connected to replica [30].

  d. Place a replica of the implant with a provisional cylinder.
  e. Fill the spaces between the imprint materials and the interim cylinder mostly with acrylic resin at the incisal border of the imprint to reproduce the replicated temporary restorations.
  f. When the material is polymerized, start preparing the interim restoration to replicate via a low-speed handpiece to produce a perfect tooth preparation that can actually support a new metal white ceramic crown or an all-ceramic crown.
  g. Scrutiny the properly made acrylic copy by using a scanner device for abutment with a customized copy-milling technique.
- Customized CAD/CAM abutment: The layout and support of dental restorations are improved by computer-assisted design and computer-assisted manufacturing (CAD/CAM) abutments, which have several advantages over stock abutments. The goal is to eliminate micromotions to preserve bone heights and reduce the likelihood of screw weakening [31]. The advantages of CAD/CAM custom abutments include the fact that they are new patient-specific, can be manufactured with precise contours to increase stability and retention, and have an emergence profile to support peri-implant tissue. The multi-step waxing, investment, casting, and polishing process is undeniably beneficial. Includes human error into a cast custom abutment [31]. The pre-machined abutment platforms of cast abutments have been discovered to be changed by heat, as shown by less implant adaptation. For CAD/CAM abutments, intrinsic casting inaccuracies are not present, which regularly show a precise fit at the implant

interface. CAD/CAM abutment also has the benefit of being an element of digital workflow; digital technology enables standard impression and model work connected with traditional laboratory processes to be eliminated. Due to the inherent archival nature of digital dental treatment, the abutment layout file can be indefinitely stored in the event that the abutment needs to be made in the future [32-35]. The initial cost of design software and milling equipment can be prohibitive when using CAD/CAM. Because porcelain can be layered directly on a cast abutment and chemically attached to the oxide layer, crowns built on cast abutments are virtually one piece with an abutment. However, because the restoration of the abutment needs to be cemented, CAD/CAM abutments comprise two sections. Compared to a cast, a CAD/CAM abutment may experience more prosthetic issues due to its inherent weakness in the interface [35].

- Hybrid abutment designated according to its finishing line: A unique design that combines two kinds of characteristics: the buccal side feather border as shown in figure 6 and the lingual side chamfer finishing line [36]. The main uses for the hybrid design are the maxillary arch's anterior esthetic area, which may spread back to the upper first molars, particularly in gum smile patients, and when the edentulous region has an excellent soft tissue dimension (3 mm), a traditional abutment layout with a clear edge can be used. If the edentulous region has bad soft tissue < 3 mm, the shoulderless abutment structure is more frequently stated [36]. In the design of a hybrid abutment, there are three distinct zones, which are buccal areas; in this part, there are no lateral elements, and this part is flat. It forms the buccal part of an unfinished normal tooth and receives the crown's feather-edge margin. Thus, the gap after cementation will be less than in the shoulder layout. The crown border will be mildly subgingival placed between 1 and 1.5 mm, enabling full removal of the excessive amount of remaining cement as shown in Figure 6 [36]. The lingual portion in this part poses a clear and obvious chamfer finish line situated supragingivelyor, if necessary, at the gingival level to increase retention in the event of short abutments. It is possible to add one or two retentive grooves in the palatal portion for this same purpose. The available margin is a significant point of contact for checking the seat of the crown, and the lateral component of the chamfer assists with occlusal stress dispersion. No subgingival cement is anticipated in this portion's absence of esthetic significance, as shown in the shoulder layout as shown in Figure 7 [36]. Proximal portion: in this portion, the lingual chamfer mixes with those of the proximal surfaces of the perfectly smooth portion without the need for a horizontal component. The flat shape offers essential space for the papillae's soft tissue with regard to the buccal side. The intracellular part of the reconstruction is freely created to keep an ideal esthetic contour, depending on the tissue level as shown in Figure 8 [36].

Fig. 6. Baccal portion [36].

Fig. 7. Palatal portion [36].

Fig. 8. Proximal portion [36].

3 Implant Abutment Interfaces

3.1 External Interface Includes

The connecting feature extends to the implant's coronal region. The screw is the only part that holds the abutment in place, and because it rests on the external connection feature, it has a high rotating center in relation to the implant [37].

3.2 Internal Interface Contact

Internal contacts, which are found inside the implant's body, have a lower contact quality than the coronal portion of the implant. A butt joint (90 degrees, essentially flaton-flat) could be the point of contact between the two structures [39].

- Morse Taper (conical) interface: A particular sort of inner link depending on the two designs 'of machine taper. A real conical bond is a press-fit Morse Taper link with substantial friction between the two parts, resulting in cold welding [40].
- Conometric link implant abutment: Pure conometric, in which the abutment and implant surfaces are directly connected via the interface and do not include screws. Its surfaces were never extremely smooth, and the small asperity caused the bond to be strengthened by cold welding as shown in Table 1 [41].

TABLE 1. Varying types of external connections [38].

Types of external connections	Design and Benefits
1- Tapered hex interface.	Adding 1.5 degrees tapering to its flattened hex. Decreased rotational liberty between both the implant and abutment, thereby reducing screw loosening incidence.
2-Outer octagon interface	Because of the design of this circular link, the link has low resistance to torquing, is not very common, and is not suitable for use with angulated dental implants. Used for replacement lower incisors
3-Spline interface	It consists of 6 outward projections from the fixture of the dental implant and is seated in 6 furrows located into the relative abutment.

4 Conclusion

The better type of abutment that can be used to connect restoration with the fixture is shape memory because it combines the retrievability of screw-retained prosthesis and the esthetic of cement-retained. Internal connection allows for reduced rotational axis, so this lessens the incidence of screw losing opposite to that found in external connection that permits for more freedom in the rotation. In contrast, the modifications in the surface of the conometric connection make it more stable. Custom abutment is preferable over prefabricated abutment because it overcomes the drawbacks of prefabricated abutment, such as aesthetic and mechanical inefficiency, especially that made by CAD/CAM technique because this technique added accuracy to custom abutment and allows better emergence profile of restoration. Modifications in the finishing line of the abutment and a combination of two different materials lead to the production of a more aesthetic and durable abutment called a hybrid abutment.

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