Review on Dental Implant with Special Reference to Tooth Abutment Implant

Shailja Awasthi, Vinay Pratap Singh and S. K. S. Yadav

Abstract In human beings, tooth loss is a common problem which may be due to various diseases and trauma. Dental implants are used to provide support for replacement of missing teeth. At the present time, research is focused on implant design, materials, and techniques for fabrication of the dental implant. There is still a lot of work involved in the use of better material, implant design, surface modification, and functionalization of surfaces to improve the long-term benefits of implant treatment. This paper provides a brief history of dental implant and its classification, success, and failure rate of a dental implant, parameters such as length, diameter, geometry, and thread used for the current tooth abutment implant. It also discusses the various complexities associated with the dental implant such as complex design and machining of the screw, its cost, failure due to the motion of implant in the transverse direction, idea to remove complexities, and current technologies.

Keywords Tooth · Dental implant · Endosteal root form

1 Introduction

The teeth are a very important part of the human body which we used to break down food ingredients by cutting and crushing them in preparation for swallowing and digesting. There are four types of teeth in humans: incisors, canines, premolars, and molars, and each tooth has some special function. The incisors teeth cut the food, the canines teeth tear the food, and the molars and premolars teeth crush the food. The roots of teeth are embedded in the upper jaw or in the lower jaw and are covered by gums. Teeth are made of multiple tissues of varying density and hardness. Figure 1 shows various types of teeth.

Tooth abutment implant plays an important role in prosthodontics and restorative dentistry since the early 1970s. Tooth abutment implant is a type of endosteal dental implant which is classified on the basis of implant design. When some problem

S. Awasthi · V. P. Singh (✉) · S. K. S. Yadav
HBTU, Kanpur, India
e-mail: vinayforus@gmail.com

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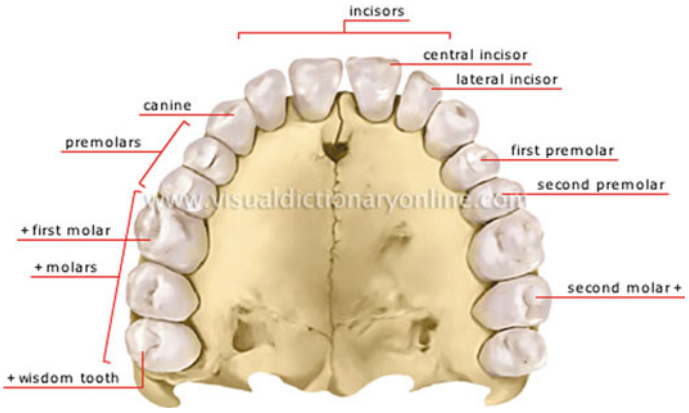

Fig. 1 Types of human teeth in lower jaw. *Source* [1]

occurs in the second premolar tooth of the human being and replacement is required then we use the tooth abutment implant as a root and place crown above it. There are three parts of this dental implant which are abutment, implant, and screw. Here, we use a screw for combining the remaining two parts (abutment and implant). Crown is mounted on the abutment and implant remain is fixed in the jaw bone. The success and failure of the implant mainly depend on the osseointegration but there are some other factors which also affect the success of the implant such as bone loss, implant design, implant parameter, surface properties, etc.

2 Dental Implant and Its Types

A dental implant is a surgical component that interfaces with jawbone to support a dental prosthesis such as a crown, bridge, denture, etc. [2].

2.1 Classification Based on Implant Design

There are four types of the dental implant on the basis of implant design (Figs. 2, 3)

1. Endosteal Implant—This type of implant is surgically implanted into the jawbone directly [3]. Endosteal implant is placed into the alveolar bone and or basal bone. Endosteal is divided into three types as given below:

   Blade implant—There is a thin plate in the form of a blade which is embedded in the bone.

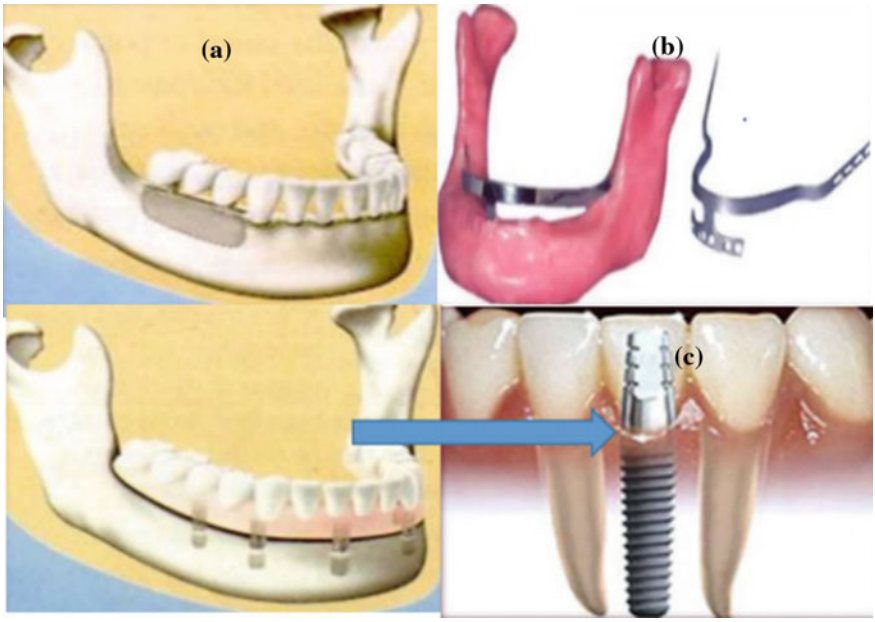

Fig. 2 Endosteal implant and its parts **a** blade implant, **b** ramus frame implant, **c** root form implant. *Source* [4]

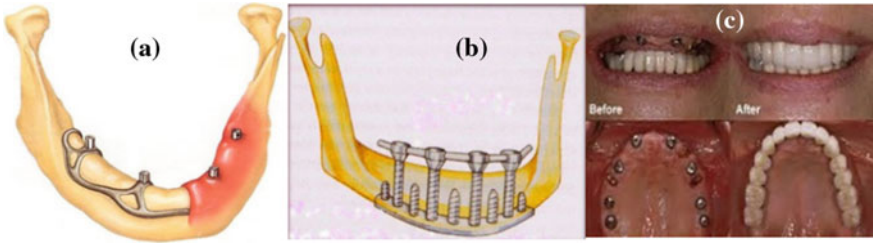

Fig. 3 Pictures of **a** subperiosteal implant, **b** transosteal implant, **c** intramucosal implant. *Source* [4]

Ramus frame implant—It is a horseshoe-shaped device which is made of stainless steel, and is inserted into the mandible from one retromolar pad to the other. Root form implant—This type of implant is designed to mimic the shape of the tooth and also for directional load distribution [3].

2. Subperiosteal implant—We can use this type of implant when all teeth are absent in the mouth or when due to lack of enough jawbone width and height. The weight of this implant is very light and this is made from metal framework, and it provides roots for multiple teeth.

3. Transosteal implant—This is also called staple bone implant or mandibular staple implantor transmandibular implant. This type of implant is used only for the lower jaw and it is made from pure titanium and its alloy.
4. Intramucosal implant—This implant is inserted into the oral mucosa. This implant is used with the removable dentures. They have a mushroom-shaped design which is fit on the upper side of the mouth.

2.2 Classification Based on Attachment Mechanism of the Implant

There are two types of dental implant (Fig. 4)

1. Osseointegration—In the osseointegration, the jawbone attaches to dental implants directly and bone grows up to the implant surface without inverting soft tissue. It takes 4 to 6 months to complete the restorations [5].
2. Fibrointegration—This process is same as osseointegration but it needs soft tissues such as fibers or cells between implant and bone to completely attach and to heal. The fiber collagen formed around the implant makes the healing process faster than actual osseointegration process. The dentist can attach the abutment and crown at the time of implant surgery itself [6].

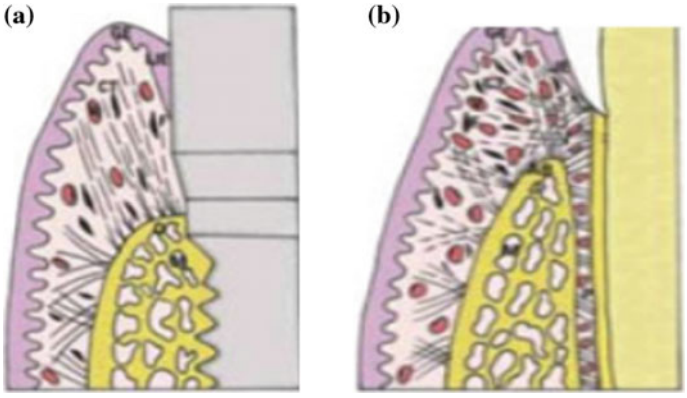

Fig. 4 Pictures of **a** osseointegration, **b** fibrointegration. *Source* [6]

2.3 *Classification Based on Macroscopic Body Design of the Implant*

There are six types of the dental implant on the basis of macroscopic body design of the implant. These are (Fig. 5) given as follows:

1. Cylindrical dental implants—These are cylindrical as the name suggest without screw threads and can be placed easily in the jawbone.
2. Threaded dental implants—We make the thread on the surface to increase its surface area and thread help in distribution of force in large peri-implant bone volume.
3. Plateau dental implants—These are plateau in shape with the sloping shoulder.
4. Perforated dental implants—These implants are of inert microporous membrane material in intimate contact with and supported by the layer of perforated metallic sheet material.
5. Solid dental implant—These type of implants of the circular cross section without any kind of hole in the body.

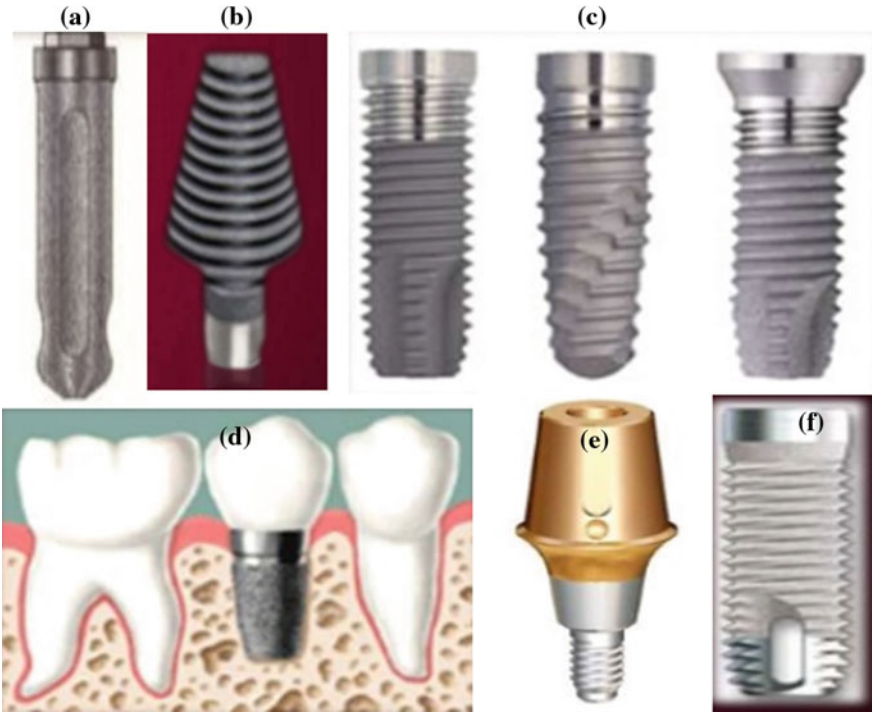

Fig. 5 Pictures of **a** cylindrical dental implant, **b** threaded dental implant, **c** plateau dental implants, **d** perforated dental implant, **e** solid dental implant, **f** hollow or vented dental implant. *Source* [7]

6. Hollow dental implants—These implants are hollow screw type and there are multiple holes in its lateral surface. These holes are used by the bone tissue for penetration into the implant, the contact area with the bone is increased, and therefore a high bonding force can be obtained.

2.4 Classification Based on the Implant Material

There are four types of dental implant on the basis of implant material (Fig. 6) which are given as follows:

1. Metallic implant—Stainless steel, cobalt chromium, molybdenum alloy, vitallium, and titanium material are used for implant.
2. Ceramic and ceramic-Coated Implant—Ceramic implants are fabricated by powder compaction or as a ceramic-coated metallic implant. The ceramic coating preferably contains a titanium oxide ceramic, zirconium oxide, etc.
3. Polymeric implant—Polymeric compounds adapted to be implanted at the external layer are those that known to be biocompatible and they have the ability to be drugged impregnated.
4. Carbon implants—Its modulus of elasticity is equivalent to the modulus of elasticity of bone and dentine.

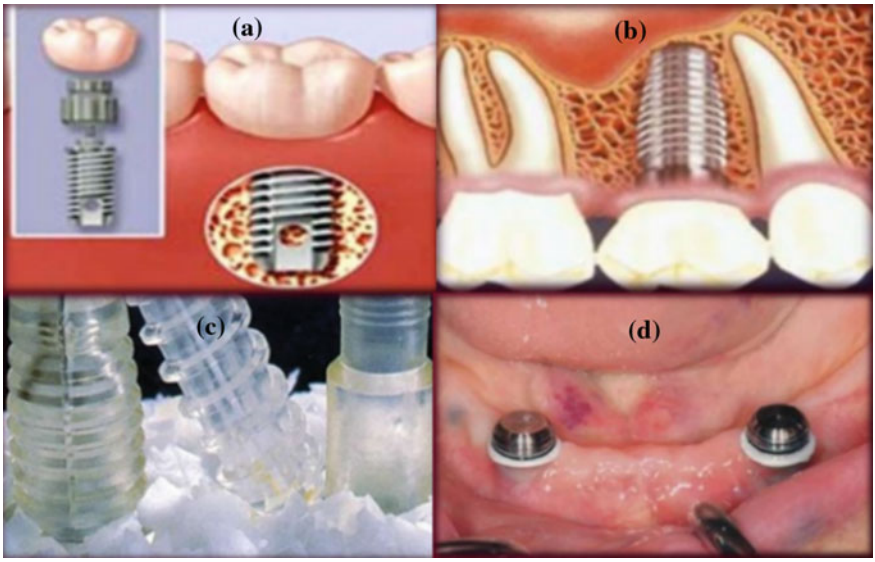

Fig. 6 Pictures of **a** metallic implant, **b** ceramic and ceramic-coated implant, **c** polymeric implant, **d** carbon implants. *Source* [8]

2.5 Classification on the Basis of the Surface of Implant

There are four types of the dental implant on the basis of the surface of the implant (Fig. 7) as given below:

1. Smooth surface implant—This type of implant has a very smooth surface as the name suggest. Smooth surface provides microbial plaque retention property.
2. Machined surface implant—Machined surface implants provide better anchorage of the implant to the bone.
3. Textured surface implant—We make the surface of the implant textured since surface roughness plays an important role in cell adhesion to surfaces of orthopedic prostheses and dental implants.
4. Coated surface implant—We generally use coated surface of the implant to improve the surface properties like hardness, the corrosion resistance of the substrate without changing the bulk materials.

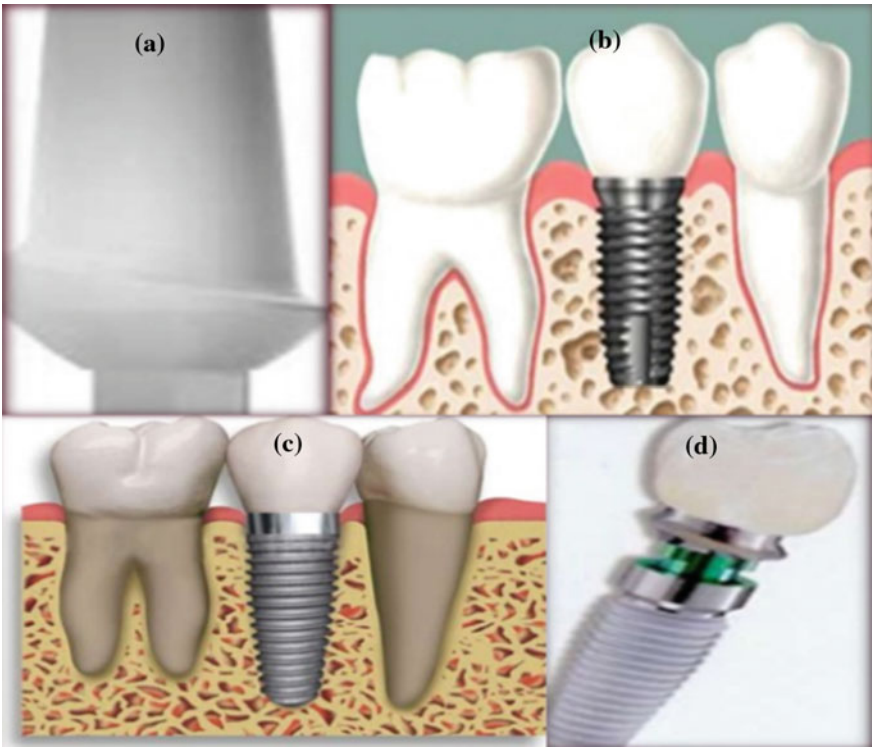

Fig. 7 Pictures of **a** smooth surface implant, **b** machined surface implant, **c** textured surface implant, **d** coated surface implant. *Source* [9]

3 Success and Failure Rates of Implant

After the missing tooth is replaced, the success of the implant is the only most important factor in treatment. Osseointegration is a key factor in implant success. We can place the implant below a denture or partial denture for stabilization and bone retention. We can use different types of the materials to make implants which include cobalt and chromium, aluminum stainless steel, titanium, etc [10]. Smeets et al. suggested that successful implants are based on the direct bone anchorage with the implant body. If we modified the surface texture up to more porous state then we will get best osseointegration. Osseointegration is an important factor in implant survival, without osseointegration it can lead to peri-implantitis and ultimately implant will fail. Periodontitis is the leading cause of tooth loss across the nation. Cho et al. state that periodontitis, a common periodontal disease, is an inflammatory disease that damages soft tissue and induces periodontium destruction. Giri and Saini, discovered peri-implantitis, like periodontitis, occurs primarily as a result of an overwhelming bacterial insult and subsequent host immune response. This can raise the risk of implant failure and bone loss in the region [11].

According to several researchers, various parameters which are related to the implant success are as follows:

(i) Immobile implant, when tested clinically,
(ii) No evidence of peri-implant radiolucency, and
(iii) Bone loss that is less than 0.2 mm annually after the implant's first year of service.

According to Esposito, following were to be considered success criteria for osseointegration implants:

(i) The absence of mobility,
(ii) Less than 0.2 mm annually thereafter, and
(iii) Absence of paresthesia.

There are many views for implant failures. According to Rosenberg et al., implant failures can be classified as infectious failures and traumatic failures. Esposito et al. classified the implant failures as biological failures, mechanical failures, iatrogenic failures, and inadequate patient education failures and Truhlar [12] classified failures as early failures and late failures. Finally, dental implant become successful when bone is comprised of homogeneous, compact bone throughout the entire jaw and bone has a core of dense trabecular bone surrounded by a thick layer of compact bone, high bone volume, clinician experience, mandibular placement, single tooth implant, implant length should be greater than 8 mm, axial loading of the implant, good oral hygiene, etc. and implant fail when bone has only a thin layer of cortical bone surrounding a core of dense trabecular bone, bone has a core of low-density trabecular bone of poor strength encased in thin cortical bone, low volume of bone, limited clinician experience, diseases like uncontrolled diabetes, HIV, etc., maxillary placement, particularly posterior region, short implant, due to acentric loading, etc.

4 Design Parameter of Endosseous (Tooth Abutment) Implant

Length

Implant length affects the stress distribution at the bone–implant interface and it also affects the success rate of the implant. There are various views about implant length [13], it can vary from 8–15 mm. If we take implant length of more than 10 mm, then it will not reduce so much the stress distribution [14, 15]. And the length of the abutment may be varied from 6 to 10 mm.

Diameter

We can vary the implant diameter from 3 to 7 mm and abutment diameter from 3 to 5 mm. Ivanoff et al. [16] concluded that larger diameter implants are more stable. Using various techniques, we find that implant diameter gives more effect on stress distribution than implant length in cortical bone but in cancellous bone implant length is predominant [17].

Geometry

Geometry is a very important factor which affects the interaction between the bone and implant, surface area, force distribution, and the implant stability [18]. There are various types of implant in the form of cylinder, conic, stepped, screw shaped, and hollow cylinder. After several studies, we found that conical implant with geometric discontinuities is best compared to smooth cylindrical or screw shaped because it provide more stress distribution.

Threads

We make the thread on the implant surface so that we can increase its surface area, improve its initial stability, and distribute stress favorably [19]. We make various threads on implant body like micro-thread on its neck part, macro-thread on its middle part and variety of altered pitch threads on its lower part [15].

4.1 Composition of Dental Implant

Titanium and its alloy is the main metallic material which is used for manufacturing of dental implant. Nowadays, we mostly make the implant of pure titanium and its alloy mainly because it is a light metal with the best biocompatibility, relatively high stiffness, and corrosion resistance [20]. Various other materials like ceramic, polymer, etc. are also being used for dental implant.

4.2 Complexities Associated with the Endosseous Implant and Its Removal

There is one major reason for implant failure which is microgap. If microgap is left after fixation, then it results in disease surrounding the implant. Microgap is the first stage of disease and due to this bone may lose or implant may fail. Sometimes this microgap occurs at the lower position of internal hexagonal connection leads to produce stress of dental implant so it increases the possibilities to be failure dental implant [21]. According to several studies, bone loss may be the reason for implant failures [22]. Implant parameters such as diameter, shape, length, and abutment type are not only the reason for bone loss but also external hex implant body abutment generated the maximum stress under vertical loading condition of forces than internal hex generated. Bone quality also affects the implant and produces more stress-like spongy bone [23]. There are some other problems occur in the implant which is related to the implant complex design. There are three parts in the tooth abutment dental implant. These are abutment, implant, and screw (Fig. 8).

For combining abutment and implant, we use a costly screw which has a very complex geometry and its machining process is very difficult so if we make a design which combine the abutment and the implant without using a screw and which make a better locking system between them then we can resolve this problem. FEA-based analysis, functionally graded materials, nanotechnology, etc. are various recent approaches used for the design of dental implants.

Fig. 8 Different parts of tooth abutment implant. *Source* [24]

5 Conclusions

A successful effort was made to review the details of various dental implants. It was observed that

1. The major classifications of dental implants are based on implant design, an attachment mechanism, macroscopic body design, implant material, and on the basis of surface of the dental implant.
2. The success of the dental implant mainly depends upon better osseointegration, the absence of mobility, surface characteristic of the dental implant, homogeneity of bone, higher volume and density of bone, clinician experience, implant parameter especially length, good oral hygiene, etc.
3. Implant failures occur mainly when there is no osseointegration, less volume and low density of bone, poor strength of the bone, less clinician experience, etc.

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