Design and Analysis of Dental Implant

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Abstract:- In human being tooth loss is a very common problem which may be due to various reasons like diseases and trauma. For solving this problem we use Dental implants which provide support for replacement of missing teeth and then we place crown above it. Research on dental implant designs, materials and techniques is continuously increasing and it depends upon the position of teeth. There is still a lot of work involved in the use of better biomaterials, 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 implants, its material and it's properties and about its parts. This research paper work describe the new designs and conventional design of dental implant and stress distribution using Finite Element Analysis method on the surface of the whole system under various loading conditions. This also describe how to remove complexities which is associated with tooth abutment implants such as its motion, complex design of screw, high cost etc.

Keywords: *Tooth, Dental Implant, Endosteal Root Form.*

1. Introduction

Dental Implant plays an important role in prosthodontics and in restorative dentistry since 1970s [1]. The design of this type of dental implant is a endosteal implant which is classified on the basis of implant design [2]. When any problem occurs in the second premolar tooth of the human being and replacement is require then we use this implant and place crown above it. In conventional design it is divided in to three parts these are abutment, implant, and screw [3]. Here implant and abutment are combined with the help of screw. After combining dental implant fix it in the jaw bone and mount crown above it. There are many factors on which success of the implant occurs like osseointegration, implant design, implant dimensions, surface properties etc. There are so many reasons due to which implant fails mainly due to occlusal overload or fatigue- induced micro damage, bone loss [4]. Bone loss mainly starts from cortical bone crestal area and progress towards the apical region. Stress field is developed around the osseointegrated dental implant due to loading (horizontal, vertical, oblique), material properties, macroscopic body design, surface properties etc [5]. In the present work model design of tooth abutment are being analyzed without the use of costly screw used in conventional abutments. Here used material is titanium alloy which has better biocompatibility, bonding strength, and higher corrosion resistance, and it prevents to fracture. Titanium alloy has some specific properties like it is homogenous, isotropic and linearly elastic material. Solidworks 3D modelling software is used for making design of dental implant and Ansys software is used for analysis [6]. The manufacturing process of screw which is used in conventional design is very difficult and expensive and there is a possibility of loosening of screw. New design of dental implant modelled to overcome these problems. During analysis applying the different type of load at different angle (Vertical, Horizontal, Oblique) depends upon the position of the jaw and then find out the best design on the basis of stress distribution. Overloading [7] and oblique loading [8] are considered very important factors in loss of osseointegration of dental implant which become main reason of implant failure [9].

2. Materials and Methods

2.1 Material for Implant

The selection of material for dental implant is mainly depends upon the mechanical properties and its biocompatibility. Past studies shows that the human biting force vary between 70 N to 150 N. Due to high biocompatibility, corrosion resistance and better mechanical properties Titanium alloy is used for making new designs of dental implant.

2.2 Procedure for Modeling and Analysis

Table 1

Property of Titanium Alloy	Value
Density	4.62e-006 kg/mm³
Coefficient of Thermal Expansion	9.4e-006 /°C
Specific Heat	5.22e+005 mJ /Kg C
Thermal Conductivity	2.19e-002 W/mm°C
Resistivity	1.7e-003 ohm mm
Compressive Yield Strength (MPa)	930
Tensile Yield Strength (MPa)	930
Tensile Ultimate Strength (MPa)	1070
Reference Temperature C	22
Poisson's Ratio	0.36
Bulk Modulus (MPa)	1.1429e+005
Shear Modulus (MPa)	35294

Modelling of the design is done by Solidworks software and analysis is done by Ansys software by using Finite Element Analysis.

Preprocessing

In the preprocessing stage geometric properties, material properties, element type, boundary condition, input parameter like (load, angles etc) are defined.

Solution- Compute the unknown parameter like Von-Mises stress, principal stress. Postprocessing – Postprocessor software contains sophisticated routines used for sorting, printing, and plotting selected results from a finite element solution.

2.3 Loading

In order to simulate the biting and chewing action of teeth, the acting force may be horizontal vertical, or oblique. Here for finding the von mises stress 80N load is choosed for normal condition.

2.4 Boundary Conditions

The models were constrained in X, Y and Z-directions on implant surface and both the components are made of titanium alloy which is homogenous, isotropic and linearly elastic material.

2.5 Design of Dental Implant

Figure 1(a) shows the conventional design of dental implant and then two new designs are proposed and analyzed.

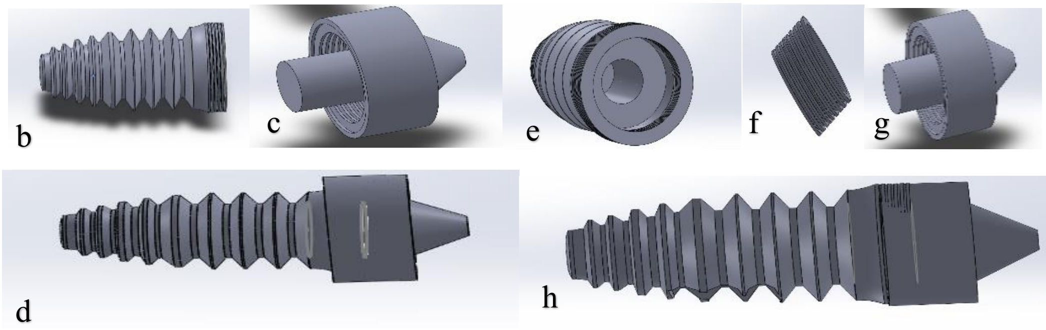

Figure 1. (a) Conventional design of Dental Implant, Parts of design 1:(b) Implant (c) Abutment (d) Assemble Design 1, Parts of design 2 (e) Implant (f) Cylindrical Threaded Part (g) Abutment (h) Assemble Design 2

Design 1- The design 1 consist two parts which are abutment and implant. Here external threads are made on implant and internal threads made on abutment. When we combine these two parts it will generate one new design.

Design 2 – The design 2 consist of three parts which are implant, cylidrical threaded part and abutment. Here internal threads are made on abutment and implant and external threads on the hollow cylindrical part. The internal thread on abutment and implant will combine with cylindrical external threaded part and will form a new design of dental implant.

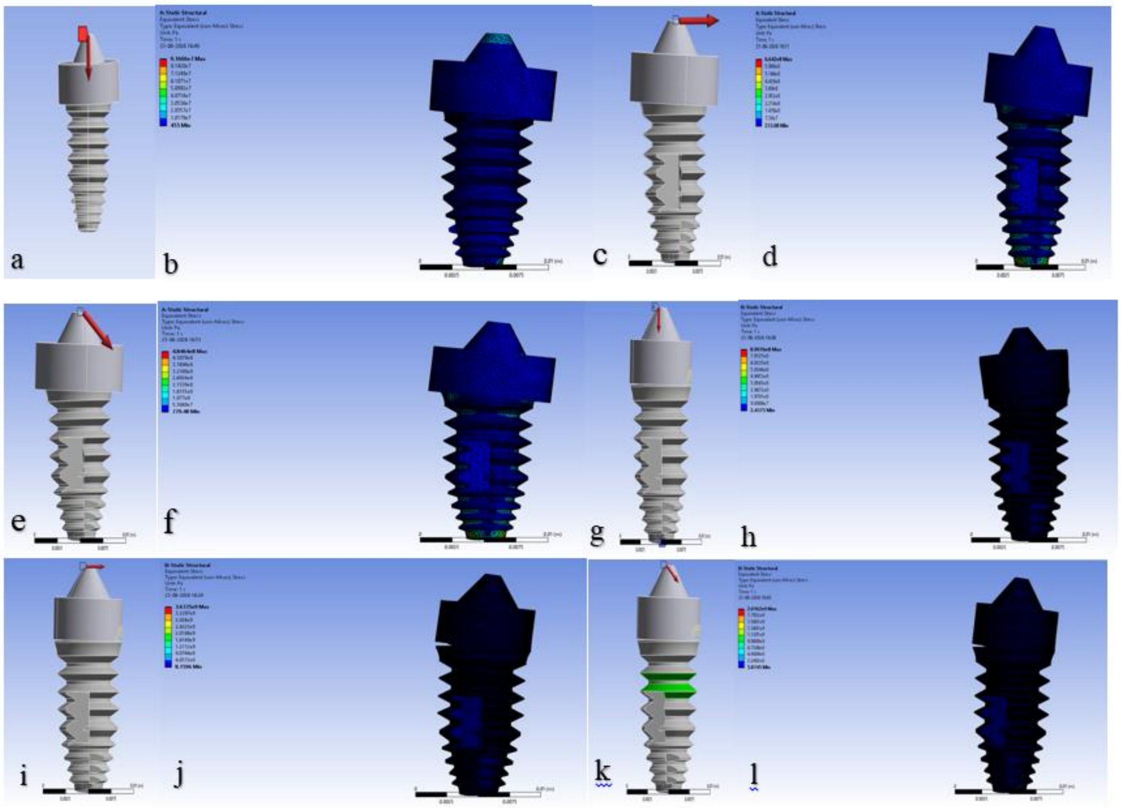

Figure 2. (a) Force direction, (b) Von-Mises stress distribution on design 1 under 80 N vertical load, (c) Force direction, (d) Von-Mises stress distribution on design 1 under 80 N horizontal load, (e) Force direction, (f) Von-Mises Stress distribution on design 1 under 80 N oblique load at 45°, (g) Force direction, (h) Von-Mises Stress distribution on design 2 under 80 N vertical load

(i) Force direction, (j) Von-Mises stress distribution on design 2 under 80 N horizontal load, (k) Force direction, (l) von-Mises Stress distribution on design 2 under 80 N oblique load at 45°

3. Results and Discussions

von-Mises stress distribution under 80 N load vertically, horizontally, and obliquely at 45° on the top surface of the abutment of design 1 and 2 is shown in Figure 2.

When we applying 80 N load on the top surface of the abutment on design 1 and 2 the value of maximum von mises stresses distribution for vertical, horizontal and for oblique (45°) are 91.606 MPa, 664.2 MPa, 484.6 MPa, 890.1 MPa, 3633.5 MPa, and 2016.2 MPa. The maximum stress occur on the interface between abutment and implant.The ultimate strength of the Titanium alloy is 1070 MPa and when we compare all the values with maximum strength then we found that our first design is safe because it's von mises stress values comes under it's ultimate strength.

Validation

The ultimate tensile strength of Titanium alloy 1070 MPa and the value of von mises stress distribution on design 1 come less than it's strength means this design is safe.

4. Conclusion

In both conventional and new designs used material is Titanium alloy which is homogeeous, isotropic, and linearly elastic and it has best bonding strength, corrosion resistance and biocompatibilty. It gives different different von mises stress values when we applying load from position on the surface of the abutment and when we compare all these values with higher strenth of the titanium alloy we found that design 1 is better in all conditions.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

References

[1] Porter JA, von Fraunhofer JA. Success or failure of dental implants? A literature review with treatment considerations. Gen Dent 2005; 53:423-32.
[2] Carranza FA, Newan MG, Takei HH. CliPerio. 9th ed. Philadelphia: Saunders; 2002.
[3] Joshi A, Shruti A. IOSR J of Dental and Medical Sciences (IOSRJDMS), Volume 11, e- ISSN: 2279-0853, 2016, p-ISSN: 2279- 0861.
[4] Esposito M, Thomsen P, Ericson LE, Sennerby L, Lekholm U. Histopathologic observations on late oral implant failures. Clin Implant Dent Relat Res 2000; 2:18-32.
[5] Watzek G. Endosseous Implants: Scientific and Clinical Aspects. Chicago: Quintessence Publishing Co.; 1996. p. 63-99.
[6] Geng JP, Tan KB, Liu GR. Application of finite element analysis in implant dentistry: A review of the literature. J Prosthet Dent 2001; 85:585-98.
[7] Santiago Junior JF, Pellizzer EP, Verri FR, de Carvalho PS. Stress analysis in bone tissue around single implants with different diameters and veneering materials: A 3-D finite element study. Mater Sci Eng C Mater Biol Appl 2013; 33:4700-14.
[8] Chun HJ, Cheong SY, Han JH, Heo SJ, Chung JP, Rhyu IC, *et al.* Evaluation of design parameters of osseointegrated dental implants using finite element analysis. J Oral Rehabil 2002; 29:565-74.
[9] Scully C. Oxford Handbook of Applied Dental Sciences. Oxford: Oxford University Press; 2003. p. 151.