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Three Dimensional Finite Element Analysis of the Stress Distribution in Bone Surrounding Two Different Implant-Tooth Assisted Overdentures

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Introduction

The dental profession and the public are aware of the problems associated with the mandibular complete denture than any other dental prosthesis. The insertion of implants for support, retention and/or stability gives better prosthesis prognosis.

The concept of implant-assisted over dentures is not new and many over denture reports were 3 to 5 years studies that may be representative of a learning curve in the use of attachments and over dentures. Due to the increased awareness of multiple clinical situations, bone density, biomechanics, and patient's desires, the number of patients benefit from additional retention and support through the help of implant-tooth supported over dentures is rapidly increasing.

In such cases of implant-tooth supported over dentures, attention should be paid to the stress distribution pattern among the supporting structures upon masticatory loading.

The effect of stress transmission on the dental structures and supporting tissues has been an interesting point for many years. Many techniques have been utilized for analysis of stresses in dental researches; each one had specific applications and limitations.

Finite element computer models of various types are widely used nowadays in fundamental biomechanics researches in dentistry. They also provide an ideal "test bed" for research and for the development of new dental materials.

Review of Literature

Dental implants

Dental implant is defined as prosthetic device of alloplastic material implanted into the oral tissues beneath the mucosal and/or the periosteal layer and/or within the bone to provide retention for fixed or removable prosthesis ***(Academy of prosthodontics 1999).***

Classification of dental implants

According to position

1. Endodontic stabilizer

It is smooth or threaded metal pin implant that extends through the root canal into the periapical bone to stabilize the mobile tooth with inadequate crown-root ratios ***(Cranin, 1999).***

2. Mucosal inserts

Stainless steel inserts attached to the tissue surface of removable prosthesis that mechanically engage undercut in surgically prepared mucosal sites. The inserts are considered with patients who are poor medical risks ***(Cranin, 1999).***

3. Subperiosteal implant

It is an implant placed beneath the periosteum resting on alveolar bone. A mandibular and maxillary subperiosteal implants are indicated

mainly in severely atrophied ridge ***(Natiell et al., 1972 and Babbush, 1985).***

4. Endosteal dental implant

It is placed into the alveolar and/or basal bone of mandible or maxilla and transecting only one cortical plate.

According to their shape:

1. Transmandibular implants

It consists of transosteal threaded posts which penetrate the full thickness of the mandible passing into the oral cavity in the parasympheseal region. They are made of either vitallium, titanium alloy or gold alloy ***(Pharoah, 1993).***

2. Ramus blade and ramus frame implants

It is attached in part to the manbibular ramus. Ramus blade implant is one piece system made of chromium-nickel based alloy. The ramus frame is a triple-blade on piece device designed for relatively atrophied mandibles ***(Richard ,1992).***

3. Blade form implant

It is wedge shaped, faciolingually narrowed dental implant bodies with vents through which tissue may grow. They are mainly indicated in knife edge ridges, especially for posterior free end saddle areas of mandible ***(Cranin, 1999).***

4. Root-form implants

It is endosteal implant shaped in the approximate form of a tooth root. These implants require a vertical column of bone (more than 13mm vertical height and more than 6mm buccolingual).

They are preferred over other types due to better stress distribution, abutment designs, and faster healing, good esthetics, and less skill requirements ***(cranin et al., 1993).***

Classification of root form implants

A. According to design

Root form implants are either cylinder or screw in form. Cylinders may be tapered, may have external threads or hollowed with fenestrations called baskets; solid screws may have external fins rather than threads ***(Misch, 2005).***

B. According to material

- **Commercially pure titanium**

It is a low density metal with high corrosion resistance having an oxide surface layer which creates a chemically non-reactive surface to the surrounding tissues. It has a modulus of elasticity five times greater than bone and poor wear resistance ***(Misch, 1999).***

- **Titanium-aluminum-validum alloy**

It has a higher modulus of elasticity, being stronger, enables it to work in thin sections without deformation ***(Misch 1999).***

- **Aluminum, titanium and zirconium oxides high ceramics**

Oxide ceramics were introduced for surgical implant devices because of their inertness to biodegradation, better color, minimal conductivity and high radiopacity. However, they have been used in bulk forms due to their brittleness and low ductility ***(Clarke et al. 2006).***

C. According to surface characteristics

- **Titanium oxide surface**

Titanium forms a surface coating of titanium oxide on which mineralized bone matrix can be formed. This titanium oxide layer provides the titanium alloy with the property of biocompatibility ***(Le Gu´ehennec 2006).***

- **Sand blasted surface**

A titanium surface that has been roughened by sandblasting will have significantly higher level of bone contact than titanium surface that are smooth and polished.

- **Plasma sprayed surface**

Plasma sprayed coating increases the surface area six times with a resultant increased implant contact to bone ***(Ogisoset et al., 1998)***

- **Hydroxyapetite coating**

Morri et al., 1997 explained that this calcium phosphate salt shows more rapid biochemical attachment to bone than does titanium due to bone growth from both surfaces of implant and the cut bone. However, the degree of osseointegration to titanium increases with time. Failure of

hyroxyapetite coating is due to either damage, dissolution or depending on the primary implant design.

- **Polyactive coating**

Application of flexible polyactive coating to the implant surface simulates the function of the periodontal ligament ***(Du 2002).***

D. According to the manner of insertion

Cranin et al. 1993 classified end osseous implants into:

Press-fit

The implant site is drilled slightly smaller than the actual implant size, and then the implant is pressed depending on friction for primary stability. They are non-thread, covered with a roughened spray coating.

Self tapping

These are threaded implants. The implant is used to tap its site during its insertion.

Pretapping

These are threaded implants, where their sites are previously tapped using bone tap instrument before insertion.

E. According to surgical technique

- **One-stage design (non submerged)**

The implant body and its abutment portion are placed as one unit in their prepared site in the jaw and the abutment portion protrudes through the oral mucosa in the oral cavity in one surgical stage. ***Abrahamsson et***

al. 1999 considered that non submerged installation decrease surgical trauma and preventing the occurrence of micro-gap between the abutment and the implant.

- **Two-stage design (submerged)**

In which, the implant body is completely inserted inside bone in the first stage surgery, then once osseointegrated, it is exposed and an abutment is added.

F. According to biologic tissue response to implant material (Misch 2005):

1. **Osseointegration caused by bio-inert materials (contact osteogenesis)**

Materials such as titanium, ceramics, tantalum, alumina and zerconia are characterized by direct bone contact. As the materials surface is chemically unreactive to the surrounding tissues and body fluids.

2. **Fibroinegration caused by bio-tolerant materials (distant osteogenesis)**

Such as stainless steel, polymers and cobalt-chromium-molybdenum are usually characterized by fibrous tissue interface.

3. **Bioinegration caused by bio-active materials (bonding osteogenesis)**

It is a biochemical bonding of living bone to the surface of an implant that is independent of any mechanical interlocking mechanism at the electron-microscope level of observation. Hydroxyapetite coating and

glass ceramics show a chemical bond caused by the presence of free calcium and phosphate compounds in the implant surface.

4. **Ligament integration caused by bio-inert materials**

Buser et al. (1999) confirmed the formation of cementum and periodontal ligament around areas of titanium implants in contact with root tips.

G. According to body design

The body geometry of endosteal implant is characterized by its cylindrical shape with 3-basic Shapes ***(Misch 2005):***

1. Threaded screw (Branemark, Nobel biocare, Golentberg, Sweden).

2. Press fit cylinder (add modum, IMZ, interpore international, Invine CA).

3. hollow basket cylinder (ITI system, Walder Enburg)

Root-form implants

A. Nobel pharma-Branemark

It is two stage titanium threaded screwed type bone taped with machined surface or conical threaded type self-tapped with sand blasted surface ***(Albrektsson and sennerby, 1991 and Cranin et al.1993).*** It is provided by external hexagonal for abutment connection which lacks the antirotational mechanism especially in single tooth restorations ***(English, 1992).***

B. Core-vent

It is combination between cylinder and screw implant. It is a hallow vented basket design in its apical portion it has an initial press fit which reduces the amount of jaw opening required to place the implants in the posterior mandible ***(Albrektsson, 1986).***

C. Screw-vent

It is made of pure titanium or titanium alloy in a solid screw design, the implant is threaded to the apex, with an apical vent and vertical cutting grooves which make it tapped. Hydroxyapatite coated screw vent is also available ***(Beaty, 1994).***

D. Micro-vent

It is hydroxapatite coated implant; it has horizontal ledges which increase the surface area, vertical grooves to resist rotation, apical threads to engage cortical bone and an apical vent for bone growth. Implants allow push in/screw in application. It is indicated mainly for anterior and posterior maxilla ***(Richard 1992).***

E. Swede-vent

It is an endosseous screw type implant prepared with an external hexagonal interface to engage the abutment ***(Richard 1992).***

F. Bio-vent

Cylinder bullet form implants, hydroxyapatite coated introduced in 1989, with apical vents and vertical grooves for antirotation. Vertical grooves eliminate hydrostatic for the easier seating of push-in design. It is best used in anterior porous mandible ***(Misch 1994).***