An experimental and finite element study considering effect of cantilever design on screw attachment and bone strain

A Research submitted for the partial fulfillment of the DD.sc Degree in Crown & Bridge, Faculty of Dentistry, Ain Shams University

By
Maged Mohammed Mohammed Zohdy
BDs , MD.Sc.
Assistant Lecturer
Faculty of Dentistry, Ain Shams University

2011

Supervisors

Dr. Amina Hamdy
Assistant Professor and head of department of
Crown & Bridge
Faculty of Dentistry, Ain Shams University

Dr. Gihan Farouk
Assistant Professor of Crown & Bridge
Faculty of Dentistry, Ain Shams University

Dr. Tarek Salah Morsi
Assistant Professor of Crown & Bridge
Faculty of Dentistry, Ain Shams University

ACKNOWLEDGEMENT

First and foremost, I am greatly thankful to ***ALLAH*** for granting me the effort & support to accomplish this work.

I am greatly honored to express my deepest gratitude to ***Dr .Amina Mohamed Hamdy*** , Assistant Professor and the head of departement of Fixed Prosthodontics, Ain-Shams University for her inspiration, encouragement and guidance which undoubtedly made this work possible.

I am deeply grateful to ***Dr.GihanFarouk***, Assistant Professor of Fixed Prosthodontics, Ain-Shams University, for her unlimited help, persistence to achieve perfection and most of all for her valuable time.

I am also deeply grateful to ***Dr. Tarek Salah Morsi***, Assistant Professor of Fixed Prosthodontics, Ain-Shams University ,for his huge unlimited knowledge and simplicity in seeking perfection

And at last I would like to express my deep gratitude to all my colleagues in the the departement for their valuable help & support through the whole course of the work

DEDICATION

I would like to dedicate this work to my precious mother, , my lovely wife and children and my all friends and colleagues for their support in the good as well as the bad days, Never forget to pray for soul of my father , may Allah rest his soul and let us meet again in heaven.

List of contents

List of figures:

List of tables:

The coincidental discovery of the tenacious affinity between living bone and titanium oxides, termed osseointegration, propelled dentistry into a new age of reconstructive dentistry.

Dentists have been able to provide different treatment options utilizing the osseointegrated tooth simulates, which improved the quality of life for many patients. For more than thirty years implant dentistry has provided patients with numerous new treatment alternatives. Starting from single implant restorations, fixed bridges in Kennedy class I and II conditions, and onto construction of complete overdentures with dramatic improvement in both stability and retention.

Yet the procedure is not free of complications, in-fact, six major categories of complications have been reported: surgical complications, implant loss, bone loss, peri-implant soft tissue complications, mechanical complications, and esthetic/phonetic complications. Of the mechanical complications a large number has been reported including loss of retention, resin and porcelain veneer fracture, overdenture fracture, opposing prosthesis fracture, prosthesis screw loosening, abutment screw loosening and implant fractures.

Data from twenty six studies combined, gave a mean abutment screw loosening of 6%(365 of 6256 screws loosened) and it was found to be as high as 45% with implant single crowns according to one study.

The instability or looseness of prosthetic retaining screws is therefore a frequently reported complication in dental implant therapy. In fact it is considered as the most common complication in single-implant supported restorations by some authors. Possible causes of screw loosening include poorly fitting frameworks, inadequate tightening force, screw settling, heavy occlusal forces, biomechanical overload, screw material

differences or designs. On the other hand, the effect of screw loosening may include: mechanical failure, damage of internal threads, marginal bone loss, biological complications such as pain, and possibly loss of osseointegration.

Rangert et al. addressed the fundamentals of the mechanical parameters that determine the load on implant units. They demonstrated that prosthesis design and implant placement have a significant influence on bone stress, as well as on screw attachment.

Conventional wisdom dictates that certain fixed partial denture (FPD) designs such as a cantilever will increase the biomechanical load and on the implant supporting structures, thus affecting both bone stress levels plus screw loosening degree. As the ultimate goal of an implant-retained prosthesis is to ensure that the esthetic and functional needs of the patient are met with minimal discomfort and limited complications.

Prosthodontic implant placement have dictated the use of cantilever FPD designs to overcome certain problems and limitations such as: alignment problems, esthetic restrictions, need for extensive bone grafting, and other critical considerations such as anatomical restrictions.

Many cantilever designs have been advocated in the dental literature, solving many of the aforementioned problems. Anterior or posterior (mesial or distal) cantilevers, the use of two or more implant abutments, or simply even substituting the design with a short third implant.

However, the effect of these designs on both bone stress and screw attachment was not studied simultaneously, therefore it was the purpose of this research to examine this effect. Results will definitely provide clinicians with better facts affecting their future judgement to the design that best fits their patients special needs.

This study was performed to assess the effect of cantilever design on bone strain and screw attachment; in implant retained fixed partial dentures, where the cantilever designs include the following categories:

1-Location of cantilever: Mesial or Distal.

2-Length of implants: different implant lengths was used, with the shortest implant being placed closest or farthest away from the cantilevered pontic.

3-Type of supra-structure: Screwed or Cemented.

4-Direction of load: Towards or Away from the cantilevered pontic.

By utilizing the following tests:

1- In-vitro study for testing the effect of:
-Type of supra-structure: Screwed or Cemented.
-Direction of load: Towards or Away from the cantilevered pontic.
On the screw attachment.

2- Finite element analysis (FEA) for testing the effect of :
-Location of cantilever: Mesial or Distal.
-Length of implants
On bone strain.

According to the Academy of Prosthodontic 2005 dental implant is defined as; "A prosthodontic device of alloplastic material ,implanted into the oral tissues beneath the mucosal and/or periosteal layers and / or within the bone to provide retention and support for fixed or removable prostheses. [1]

While the American Dental Association (ADA) Organization defined implants as; "Material inserted or grafted into tissue. "A device specially designed to be placed surgically within or on the mandibular or maxillary bone as a means of providing for dental replacement; endosteal (endosseous); eposteal (subperiosteal); transosteal (transosseous). [2]

According to the dental Glossary, dental implants are used to replace missing teeth. A dental implant is a false tooth that is permanently secured to the jaw. A small titanium rod will be fixed into the jawbone, and once the jawbone has adhered to the structure, a false tooth will be attached to it. [3]

According to Encyclopedia of Surgery, dental implants are surgically fixed substitutes for roots of missing teeth. If embedded in the jawbone, they act as anchors for a replacement tooth, also known as a crown, or a full set of replacement teeth. [4]

Evolution of Implant Designs:

The earliest implant attempts date back in history to the old Pharaonic Egyptian civilization. Their early implantation attempts were probably only in corpses and only limited to the higher class of the society. These attempts were driven by their religious beliefs; that the body has to be buried in the best shape possible, so that it would enjoy full function upon revival. Their writings of implantation of animal and carved ivory teeth are the oldest documentation of primitive implantology. [5]

The ancient south American civilization is also credited with evidence of early attempts to replace lost teeth by using artificial teeth carved from stone.[6] From the same era a mandible fragment dating back to 600 A.D. (Anno Domini) now present at Harvard University contained three tooth shaped shell pieces placed in the sockets of missing lower incisors presumably placed during the person's life. [7]

The era of allotransplantation

Allotransplantation of natural teeth to the upper wealthy class of society was a common procedure during the eighteenth and nineteenth centuries, especially in the western civilization. Natural teeth were extracted from poor individuals who used to sell their teeth for money. [8] The transplants were unpredictable, often complicated by infection and rejection, but in some cases, it lasted for a considerable amount of time lasting from a few years up to 25 years. [8]

Allotransplantation of human teeth was faced with some opposition, Philip Pfaff [9] in 1756 was the first researcher to point out the possibility of disease transmission through this procedure .

This idea was continued well during the twentieth century and tooth banks were established in the 1970's. They obtained donor teeth usually from those extracted for orthodontic reasons. The teeth were preserved in refrigerated tissue culture. Upon transplantation, they only had a survival expectancy of five to ten years. The idea began to fall into disuse with the advance in osseointegrated implants and the fear of transmission of the AIDS virus. [10, 11]

Early attempts in modern implantology

The earliest attempt reported for placement of an endosseous implant is probably by Moggiolo in 1809. He placed a single staged 18 carat gold implant into a fresh extraction socket, just above the gingiva . [5, 12] Unfortunately, the placement of these implants was usually followed by gingival inflammation and severe pain that frequently led to their removal. [12]

In 1886, Drs. Edmunds and Harris implanted a platinum post and a porcelain crown into an artificially created socket in the alveolar bone. The platinum post was covered by a layer of lead that was melted around it and subsequently roughened for increased retention. It was reported that this implant was still in function after 27 years of its initial placement. [13]

Until the turn of the twentieth century, many researchers and innovators continued to come up with novel designs, devices and materials all seeking the same goal. They demonstrated their work and ideas to different dental societies and meetings, but were frequently rejected or harshly criticized. [14, 15, 16, 17]

Dr.Greenfield ES presented his well known classic paper in Philadelphia 1913. He introduced his work of eight years to the Academy of Stomatology and presented a novel technique and ideas in hope to make implantation a permanent operation. His technique is thought to be the forerunner of the hollow cylinder implant of modern implantology. Greenfield used a trephine mounted on a handpiece to drill a precise trough in the alveolar bone, leaving a solid core of bone in the center of this trough.

Prefabricated hollow cylinder implants of irido-platinum wire were inserted to fit exactly in these troughs and later were fitted with an artificial crown that was attached to the cylinder through a slot at the top of the implant. [13, 14]

In 1937, Adams presented the first submergible threaded cylindrical implant, His design even included a smooth gingival collar and a healing cap. The implant was cemented to an overdenture and allowed some vertical and lateral movements. [18]

Strock placed the first successful oral implants in 1937 at Harvard University using a vitallium implant in bone immediately after tooth extraction and it shows successful results. [19]

From the mid 1930 evolved several implant concepts as subperiosteal implant first placed by Gustav Dahl [20] in 1948 , Endosteal Blade Implant introduced by Leonard Linkow and Ralph and Harold Roberts in 1967.[21,22]

It was till 1952 that dental implant produced a major leap when Branemark an orthopedic surgeon in the university of Lund, Sweden, experimented the fusion of titanium cylinder into the thigh bone of a rabbit and several researches followed and it was not until 1981 enough data to Branemark and his team to publish landmark paper for the doubts of scientific community. [23]

Classification of dental implants:

Branemark et al. [23], Weiss [24] and Worthington [25] classified dental implants according to their anatomical relation to the bone into the following categories: