STRESS DISTRIBUTION WITH DIFFERENT ANGULATION OF IMPLANT WITH OR WITHOUT CANTILEVER EXTENSION: A SYSTEMATIC REVIEW

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Abstract

Title: Stress Distribution with Different Angulation of Implant with Or Without Cantilever Extension: A Systematic Review

Introduction: To systematically review the literature on stress distribution of implants with different angulation and the effect of cantilever prosthesis.

Study Design: The three major electronic databases were screened: MEDLINE (via PubMed), and SCOPUS and ELSEVIER

Review: Methodological quality assessment showed sample size calculation to be reported by only one study, and follow-up did not include a large number of participants - a fact that may introduce bias and lead to misleading interpretations of the study results.

Conclusions: A systematic review of the current literature showed only in vitro evidence that there is no consensus on the advantage of using an offset configuration implant compared to those in straight-line configuration, well some studies shown significant improvement of bone stress distribution when an angulated implant is under oblique loading.

Keywords: Dental implants, implant-retained dental Prosthesis, prosthodontics, biomechanics.

INTRODUCTION

Implant supported prosthesis has become a routine dental treatment. To achieve the best outcome, careful consideration of technical and biomechanical parameters, is essential[1]. The rehabilitation of the posterior region of the jaw is complex, mainly due to greater masticatory forces when compared with the anterior region. In this region, implants used to retain the three-element prostheses are normally placed in a straight line. . It has been reported that the role of implant length is more significant in reducing bone stress and improving the implant-abutment stability in comparison with implant diameter.[2,3] Nevertheless, a small displacement of the central implant to the buccal or lingual area has been suggested, featuring an offset configuration, whose purpose, theoretically, is a stress distribution more favorable to prosthetic components, implant, and bone.

Distal cantilevers have been discussed in fixed prosthodontics as a method to re-establish occlusion when there are no posterior teeth to support a prosthesis. Extrapolation of the findings in natural dentition toward implant dentistry has lead to considerable debate within the dental implant community. According to Misch, under ideal conditions, the distal cantilever should not extend 2.5 times the A-P spread. Parafunction, crown height, masticatory dynamics, gender, age, and arch location will determine the magnitude and direction of force. While, number of implants, width, length, design, and bone density will determine the functional surface area. [4]

There are various implant dentistry treatment concepts using distal cantilever prosthesis with reports of long-term success.

Some of the reasons for incorporating the distal cantilever design in implant supported prostheses include a reduction in the number of implants used to support a prosthesis, which also has a concomitant reduction in the cost of the restorations; a decreased need for surgical intervention; and a simplification of surgery in those anatomical areas that are associated with the inferior alveolar nerve vascular bundle or the sinus floor. When planning a distal cantilever, factors such as abutment selection, control of the magnitude of forces, and rigidity/strength of connectors are not fully understood.

Methods of restoring tissues are very complicated and difficult; meanwhile several studies have described the advantages of rebuilding the function through cantilever fixed pros thesis [5,6] which resulted in high application of cantilever in implant supported fixed pros thesis. Since the impact of a cantilever is similar to a force being exerted by an class I lever [7,8], biomechanical force in implant supported prosthesis might jeopardize the health of its supporting bone [9].

Materials and methods

Procedure

The studies based on inclusion and exclusion criteria, analyzing and including all potentially eligible studies. All abstracts and full texts were reviewed. No authors were contacted. Disagreements among the authors were assessed, The study standard was the criteria for a systematic review proposed by the PRISMA (Preferred Reporting Items for Systematic reviews). The PRISMA statement consists of a 27-item checklist and a four-phase flow diagram. Its aim is to help authors improve the reporting of systematic reviews and meta-analyses.

Search strategy

Independent reviewer conducted a search on PubMed/Google scholar, for studies published in English, from January 1, 2007 to January 17, 2020. The keywords used were “angle” and “dental implant,” and search details were: angle [All Fields] AND (“dental implants” [MeSH Terms] OR (“dental” [All Fields] AND “implants” [All Fields]) OR “dental implants” [All Fields] OR (“dental” [All Fields] AND “implant” [All Fields]) OR “dental implant” [All Fields]). To avoid bias in the search strategy.
The following keywords were used: “angle” and “stress distribution,” “angle” and “bone,” “cantilever” and “jaw,” “angle” and “maxilla,” “angle” and “mandible,” “angle” and “dental implant,” “angle” and “stress distribution,” “angle” and “bone,” “angle” and “jaw,” “angle” and “maxilla,” “angle” and “mandible,” “cantilever and “dental implant,” “cantilever” and “stress distribution,” “cantilever” and “bone,” “cantilever” and “jaw,” “cantilever” and

"maxilla," "cantilever" and "mandible," "angle" and "prostheses," "angle" and "prostheses," "cantilever" and "prostheses," and "angulation."

Criteria for selection of studies

Initially, the selection of studies focused on analyzing the title and abstract and computer simulations were considered eligible studies were analyzed and included in the sample. Thus, population, intervention, comparison, and outcome (PICO), as recommended by the PRISMA statement, were determined as questioning criteria to organize an objective clinical question and an appropriate inclusion focus. [10,11]

Population: Experiments that performed studies with osseointegrated dental implants;

Intervention: Implant placement in different angulation

Comparison: Implants with different angulation with cantilever or without cantilever extension

Outcome: Possible differences between the positions on bone stress distribution.

The PICO question was structured as follows:

What is the effect of different anglution of implant configuration with or without cantilever extension?

Inclusion criteria

After the initial search, inclusion criteria were: studies that related the different implant angulation and cantilever lenght in computer simulation finite element analysis published in English.

Exclusion criteria

The exclusion criteria were: studies unrelated to angulation and single implant placement, duplicated studies, studies not published in English.

Quality assessment

The assessment of methodology quality was based on the PRISMA statement

Data analysis

Data were obtained similarly from all included studies, in this order: first author, year, type of study, implant used in the study,location of the implant placed, type of the bone, diameter, length, angulation, and arch jaw.

Results

General outcomes

A total of HUNDRED titles were identified with the initial search. SIXwere selected based on title and abstract

STUDIES	UNCLEAR	MODERATE	HIGH
A. Fazel et al		#	
Marco Bevilacqua et at		#	
Ebadian Behnaz et al		#	
Fariba Saleh Saber et al		#	
Mostafa Pirmoradian et al		#	
Anju Kumari et al		#	

The quality of the studies had MODERATE Risk Of BIAS suggesting appropriate methodological process of the study.

TOOL FOR RISK OF BIAS

All the included studies are comparative studies so the **GRACE TOOL** was used to evaluate the quality of the studies.

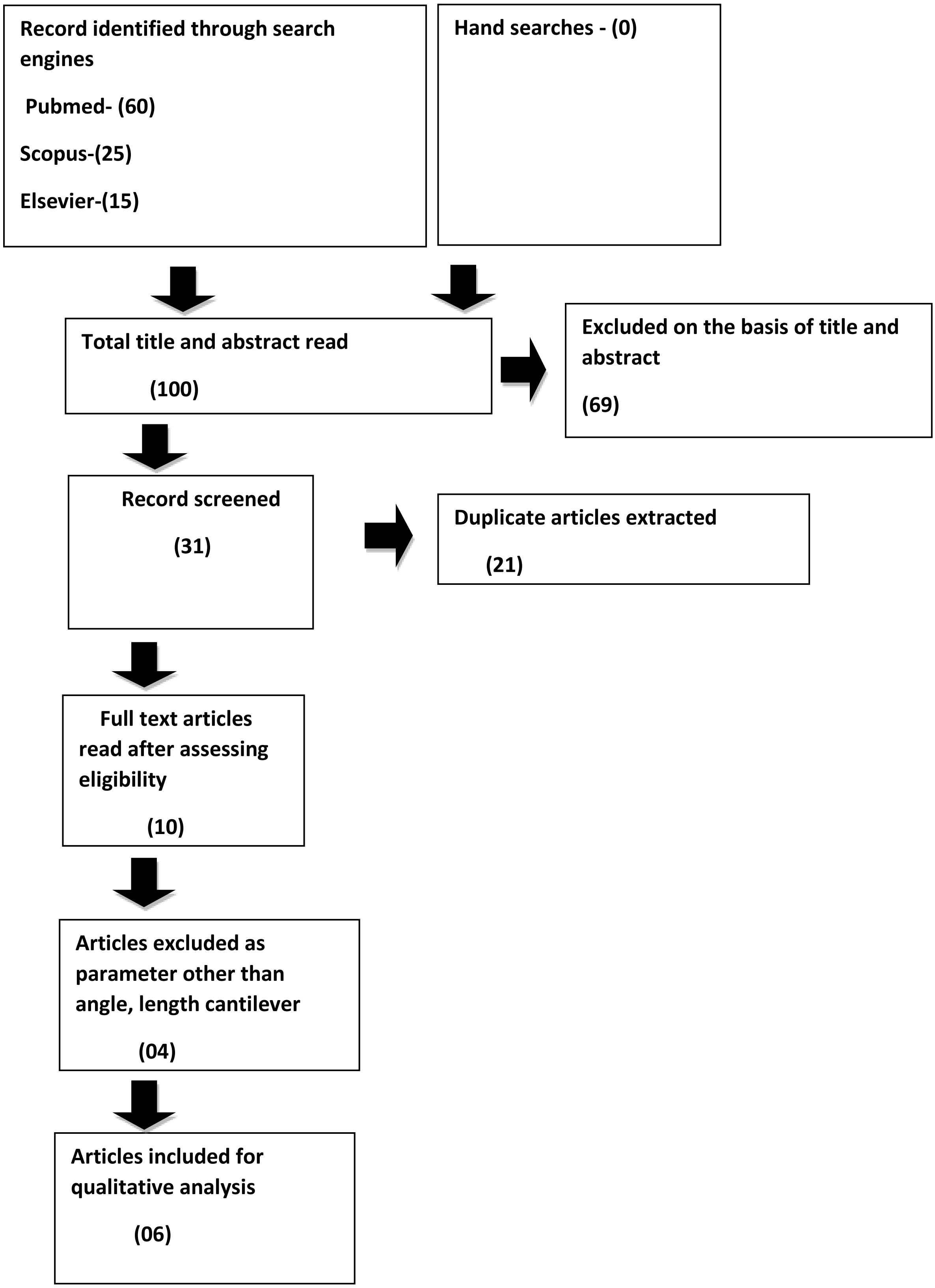
GRACE TOOL : Good Research For Comparative Effectiveness.

3D FEA

Three-dimensional finite element stress analysis is a numeric simulation determining stress and displacements via models of geometrically complex structures like dental implants. This model allows simulated force application to specifilic points in the system, and provides the resultant forces in the surrounding structures .

This form of study uses qualitative data to find that the main advantage of offset confifiguration implants is better stress distribution to bone tissue, especially against oblique loading (horizontal), but, in axial load application and regarding stress distribution, no advantage was observed in the use of offset implants. Studies mostly used implants angulation as zero degrees(0) to fourty five degrees(45)

PRISMA FLOW DIAGRAM



Discussion

With the advent of the Brånemark approach utilizing complete-arch implant-supported cantilever prostheses, the distal cantilever has gained acceptance in implant dentistry. Technical complications such as fracture of the acrylic resin teeth and prosthesis base were causes for failures for mandibular fixed implant supported rehabilitations with distal cantilevers.

Some authors attempted to summarize the causes of failures/complications of implants in association with distal cantilevers. Insufficient metal thickness, inferior solder joints, parafunctional habits of patients, incorrect framework design, excessive cantilever length, and inadequate strength of alloys have all been reported as causes of prosthesis failure.

In some studies the results showed that stress declined around the cervical area of posterior implants in cancellous and cortical bone as the angle increased and spread distally along crestal bone.

In other words, the more vertical are the posterior implants and the longer the cantilever prosthesis, the higher and concentrated becomes the von Mises stress.

Data summary of the articles selected

STUDY ID	SAMPLE SIZE	IMPLANT USED IN THE STUDY	LOCATION OF IMPLANT PLACED	TYPE OF BONE
A. Fazel et al 2007[12]	One hundred and fifty nine patients who were treated by 482 implants supported fixed partial prosthesis with and without cantilever after at least four years of treatment.	ITI and Branemark implant	maxilla and mandible	marginal bone
Marco Bevilacqua eT al 2011[13]	4 models Inclination and {cantilever extensions} 1. 0 degree - 13 mm 2. 15 degree - 9mm 3. 30 degree- 5 mm 4.45 degree- 0 mm	Four, 4-mm-diameter, cylindrical screw type implants with smooth apices (Biomet 3i, Palm Beach Gardens)	pre-maxilla	cancellous and cortical bone

Ebadian Behnaz et al 2015[14]	3 MODELS MODEL 1: Both implants, parallel to adjacent teeth, with straight abutments MODEL 2 :Anterior implant with 15 mesial angulations and posterior implant were placed parallel to adjacent tooth MODEL 3: Both implants with 15 mesial angulations and parallel to each other with 15° angulated abutments	(Biohoraizons Internal, Implant system Inc., Birmingham, Al, USA)	mandibular model, two fixture analogs10.5 mm, with 4.5 mm diameter abutment platform with 3 mm distance to each other were embedded parallel to each other by dental surveyor.	cortical bone
Fariba Saleh Saber et al 2015[15]	5 MODELS distal implants inclined 1MODEL - 0degrees 2MODEL 15degrees 3MODEL-30degrees 4MODEL-45degrees 5 MODEL- , six vertical implants were placed	Nobel Biocare	Model I: with four vertical implants. Model II: with 4 implants while posterior implants of both sides are tilted 15 degrees to distal. Model III: with 4 implants while posterior implants of both sides are titled 30 degrees to the distal. Model IV: with 4 implants and posterior implants of both sides are tilted 45 degrees to the distal. Model V: with six vertical implants.	Cortical Bone
Mostafa Pirmoradian et al 20191[16]	Three dimensional FE models of implant-abutment, cortical bone and cancellous bone are created by considering a variation of 0.6 mm to 1 mm on threads pitch while the implant lengths range from 8.5 mm to 13 mm.	----------------	Mandible	cortical bones, and cancellous bones
Anju Kumari et al 2021[17]	Three different configurations, corresponding to 3 tilt degrees of the distal implants (30°, 40°, and 45°) were subjected to 4 loading simulations. (4 mm, 8 mm, 12 mm, 16 mm)	----------------	Edentulous maxilla	Cortical bone Cancellous bone

Summary of each study

STUDY	SUMMARY	MODEL
A. Fazel et al 2007	The cantilever design has a significant influence on stress distribution in implant and its supporting tissues and can lead to unfavorable biomechanical effects around them Furthermore, finite element studies revealed that higher stress concentrations developed in models with cantilever prostheses	3D FEA
Marco Bevilacqua eT al 2011	The maximum stress values recorded in compact bone for the vertical implants were 75.0 MPa for the distal implants and 35.0 MPa for the mesial implants The maximum stresses for the 45-degree tilted distal implants were reduced to 19.9 MPa for the distal implants and 7.8 MPa for the mesial implants . Maximum stress values for vertical implants in cancellous bone were 68.6 MPa for distal implants and 30.0 MPa for mesial implants Maximum stresses for the 45-degree tilted distal implants were reduced to 15.5 MPa for distal implants and 5.7 MPa for mesial implants. The use of distal tilted implants results in a reduction in stresses in the periimplant bone and in metal frameworks secondary to cantilever length reduction and implant length increase.	3D FEA
Ebadian Behnaz et al 2015	Maximum stress values in splinted restorations of straight abutments (model 1) were lower than nonsplinted restorations (model 2) Maximum stress values in the straight implant body (130.4 Mpa) and it is surrounded cortical bone in premolar site (57.93) were more than other sites and another models. In third model maximum stress value of cortical bone around angulated premolar implant in splinted simulation was more than straight position (21.41 Mpa)	3D FEA
Fariba Saleh Saber et al 2015	MODEL 1:The maximum von Mises stress is 51.69 MPa MODEL 2:The maximum von Mises stress is 46 MPa MODEL 3:The maximum Von Mises stress is 33.24 MPa MODEL 4:The maximum von miss stress is 20 MPa MODEL 5:The maximum von miss stress is 19.89 MPa	3D FEA
Mostafa Pirmoradian et al 2019	significant correlation can be observed between maximum von Mises stress in cancellous bone, cortical bone, and implant-abutment the cancellous bone, cortical bone, and implant-abutment, the lowest von Mises stresses occur when the ratio of threads pitch to length is between 0.05 to 0.07.	3D FEA

Anju Kumari et al 2021	1. At 30° angulation of distal implant a maximum cantilever length of 16 mm may be given if the quality of bone is D3 but only 8 mm cantilever may be recommended if bone quality is D4 2. At 40°angulation of distal implant, 16 mm cantilever may be given if bone quality is D3 and no cantilever is recommended if bone quality is D4 3. At 45° angulation of distal implant only 12 mm cantilever may be given with D3 bone and no cantilever is recommended with D4 bone.	3D FEA

CONCLUSION:

A systematic review of the current literature showed only finite element analysis evidence that there is advantage of using an angulated configuration implant compared to those in straight-line configuration. After a systematic review of the literature and a traditional literature review, it can be concluded that, based upon the use of distally tilted, number of implants, length of the implant, or with the cantilever or without cantilever support.

The stress declined in both cancellous and cortical bones but the reduction is only significant in cancellous bone. Increasing the inclination in posterior implant resulting reduction of cantilever length and maximum stress reduction in bone.
The effect of cantilever length is a dominant factor and can diminish stress even with lower number of implants. Angulations of the implant can reduce cantilever forces when the applied load is in the same direction of implant angulations.

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