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The Effect of Different Dental Implant Thread Designs on Stress Distribution on Bone – A Systematic Review

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ABSTRACT

Almost all earlier mechanical analysis of implants presumed bone as an isotropic material while the bone is anisotropic. Clinically, an implant never attains total contact with the adjacent bone. The study aims at examining the result of three implant thread designs on stress dissipation features on the bone. We aimed to assess the result of three implant thread design on stress dissipation on the bone. An online search was made for the articles using Google Scholar, Ebscohost and PubMed. Articles published in the English language or those articles that have a detailed summary in the English language were included. Articles published between 1st January 2010 and 31st October 2019 were selected. Scientific research papers, Randomized controlled trials were included with data on the result of varying implant thread designs on stress dissipation on the bone. Out of 1234 articles that were identified through electronic database searching. 18 articles were selected. These articles were screened for duplicates and 4 articles were obtained after eliminating the duplicates. None were excluded after the screening of the duplicate articles. This review provides an understanding of the effect of various abutment connections on the loosening of the screw. Out of all the studies evaluated, 2 studies stated that Square thread design showed the least stress distribution for all degree of osseointegration while 2 other studies showed V-shaped thread design with minimum stress design.

Key Words: Thread design, Implant, Stress distribution, Reverse buttress, Analysis, Implant-bone interface, Implant screw loosening

INTRODUCTION

Implants have become a vital option for the replacement of the missing teeth.[1] The function of dental implants is to distribute the load to the adjacent anatomical structures. Therefore, the chief functional design objective is to transfer biomechanical loads to enhance the function of the implant-supported prosthesis.[2] The thread geometry of implant is a major factor in the biomechanical properties of dental implants.[3] Thread geometry may vary according to pitch, depth and shape.[2,4] Even though stress distribution may be affected with different thread pitch and depth, the manufacturers more commonly provide implant systems with constant pitch and depth.[5] So, a superior design of threads is required for commercial implant system.[5]

Thread designs improve primary contact, increase surface area and facilitates the distribution of the stresses at the bone and implant surface.[6] The thread designs usually used in dental implants are square, v-threads and reverse buttress.[2] The success of dental implants depends on several factors. Stress dissipation at the bone-implant interface is one of the main factors.[7] Compressive stress of some amount is necessary to initiate osseointegration while excess stress results in implant failure in the form of bone resorption.[8] More compressive load transfer is provided on the reduction of shear loading at the interface of thread and bone which is particularly a crucial factor in D3 and D4 bone situations.[2]

The current study is used to examine the result of three implant thread geometry on stress dissipation properties

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at adjacent anatomic structures. The main focus of this study is to determine an optimum basic thread design among three thread profiles i.e square, v-threads and reverse buttress.[9]

MATERIALS AND METHODS

Eligibility Criteria

Inclusion Criteria

- Articles between 1St Jan 2009-31st Oct 2019
- Articles in English language or the articles that can be translated into English
- All full-text articles
- In vitro studies
- Randomized controlled trial

Exclusion Criteria

- Articles that are in a language other than English.
- Articles with full text not available.
- Review articles.
- Letters to editors
- Case reports.

PICOS: Table 1 shows the required component and its description

Table 1: Required component and its description for study design.

Component	Description
P (Product)	Single-tooth implant posterior
I (Intervention)	reverse buttress thread design, v-thread design
C (Comparison)	Square thread design
O (Outcome)	Stress distribution
S (Study design)	Randomized controlled trials

INFORMATION SOURCES

PubMed, Ebsco and Google scholar were the three databases that were used to complete the findings for all full-text articles available. Lists of the cross-reference of the chosen articles were checked for papers that might meet the suitable criteria of the study. The search was done for studies published from 1St Jan 2010 to 31st Oct 2019.

Search Strategy

The comprehensive data search was done on PubMed, Ebsco and Google scholar. Articles published from 1st Jan 2010 to 31st Oct 2019 were included. Articles in the English language were selected. Filters for full text and study designs were not applied. The keywords used for searching articles in PubMed are given in table 2.

Table 2: Search Strategy

Sr. No	Search Strategy	Total Number of Articles	Number of Selected Articles	Number of articles after duplicate removal
1	thread design	160	4	3
2	dental implant AND thread design AND stress distribution AND finite element analysis	55	6	3
3	dental implant AND finite element analysis AND thread design	91	4	3
4	Dental implant AND thread design	400	5	2
4	Others	528	1	1
	Total	1234	20	11

STUDY SELECTION

All articles were searched with the help of the above-mentioned search strategy. For screening of articles, initially, titles and abstracts were used to identify full articles concerning the result of varying implant thread geometry on the stress dissipation on the bone. After the articles were identified, duplicates from the respective searches were pulled out. In the final step, these articles were subjected to exclusion and inclusion criteria for the review.[10]

Data were extracted independently by the first author and the data extraction was confirmed by other review authors. The difference of any opinion between the reviewers was resolved with dialogue. After this, a data extraction sheet was prepared.

DATA COLLECTION PROCESS

Significant data from the selected articles were recorded for screw loosening depending on connection design. A standard pilot form in excel sheet was used. Data extraction was first done for one of the selected articles according to the form and was evaluated by an expert and finalized. Data extraction was then done for all the remaining articles.

DATA ITEMS

Selected articles were read thoroughly and the data was segregated under the following headings in an excel sheet.

1. Study ID – Serial number.
2. Author – Author name.
3. Publication Year – When the article was published.
4. Location – Where the study was conducted.
5. Comparison Groups –Different implant thread designs
6. Sample Size of implants – Number of implants tested.
7. Brand Of Implant
8. Method of Loading – the method used for loading of the implant
9. Outcome – Amount of stress distribution to the surrounding bone
10. Results - Which implant thread design distributes minimum stress to the surrounding bone
11. Remarks - Comments of the author
12. Other Observations

STUDY SELECTION

One review author(AN) screened independently the titles and abstracts obtained by search strategy and included them to check if they met the inclusion criteria. Later full texts of all the included studies were obtained. After obtaining the full texts of the articles they were screened after reading the whole article and then decided if they met the inclusion criteria. Whenever there was any doubt regarding any study if it was eligible for inclusion, the problem was resolved via discussion with the second author(NB). Ultimately, 3 studies were included in the systematic review. All the recorded articles had been recorded with reasoning for the exclusion of each study. None of the authors was blinded to the journal titles, study or the institutions where the study was conducted (Figure 1).

706 Records were identified through the data search using search strategy in Pub Med while 528 articles were identified through Ebsco and other search engines. The second step was screening through the titles and after the screening, 1227 articles were excluded because they were not related to the objectives of the systematic review. Some articles mentioned studies done in vitro, some focused on osseointegration while the others did no study on stress distribution. 29 articles which remained were screened for duplicates manually. Out of 29 articles, 9 articles were found to be duplicates and hence remaining 11 articles were screened through abstracts as a next step. Finally, 4 articles were screened for full text. At the end, 4 studies remained which underwent qualitative synthesis (Table 3)**.**

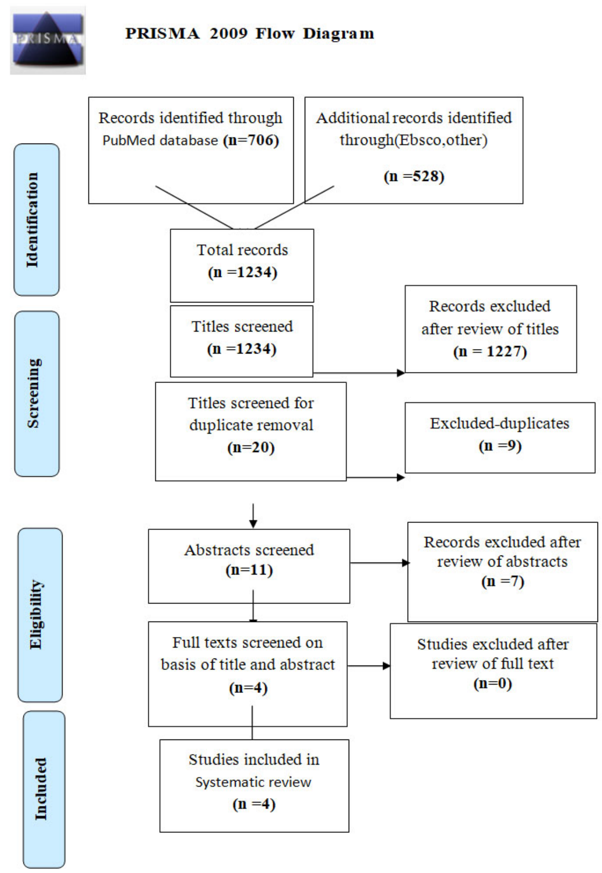

Figure 1: Preliminary screening consisted of 1234 studies.

Table 3: Preliminary screening of Articles for study

1	Study ID	Authors	Year of publication	Location	Intervention	Comparison	Brand of Implant	Sample size(N)	Sample size in	Method of Loading	Load(N)	Outcome(Mpa)		Results	Remark
2												Cortical bone	Cancellous bone		
3	1	Mosavar A, et al	2015	Iran	V shped		Straumann	4	1	Vertical occlusal load was applied with 60 Mpa compressive stress	410	147.6	9.11	Square thread showed the lowest stress for all degress of osseointegration	
4					Reserve buttress				1			149	10.46		
5						Square			1			143.6	17.77		
6	2	Nam Ok-hyun, et al	2015	Korea	V thread		Straumann	4	1	Force was applied on implant abutment from the top at 30 degree to implant axis	100		40	Square thread design has the least value of stress.	The values for the stress on different thread designs were not mentioned exactly
7					Reverse buttress				1				40		
8						Square			1				35		
9	3	Oguz Iraslan, et al	Jun-09	Turkey	V thread		Straumann	4	1	Static axial occlusal load was applied to occlusal surface of abutment	100	17.7		Minimum stress intensity area was observed with V-thread shape.	
10					Reverse buttress				1			18.2			
11						Square			1			17.3			
12	4	Pankaj Dhatrak	Jul-05	India	V thread		Biohorizon, Osstem	3	1	Occlusal load was applied vertically to implant model.	300		2.37	V thread profile is the best among the three	The average of mean value was taken for each thread design
13					Reverse buttress				1				2.63		
14						square			1				3.18		
15															
16															

RESULTS

Out of the 4 studies, 2 studies stated that Square thread design showed the least stress distribution for all degree of osseointegration while 2 other studies showed V-shaped thread design with minimum stress design.

Some studies don't give a definite conclusion because of the smaller sample sizes, differences in implant system used for the study, variety of groups compared, and relevant articles being available in languages other than English. The stress distribution pattern was not affected by the different use of implant thread designs and various osseointegration conditions.

DISCUSSION

Several studies have been conducted to assess the result of varying implant thread designs on stress dissipation on bone This systematic review has been endeavoured to find the best available evidence to establish which implant thread design dissipates the least force on the surrounding bone. However, it is difficult to draw inference from the articles selected as they cannot be compared directly due to the diversity of eligibility criteria's, assessment methods and outcomes. Seven papers were identified and included.[12] The consequence of varying thread geometry of implant on stress dissipation in the peri-implant bone are observed. Four different implant thread designs were compared i.e buttress, reverse buttress, square and v-shaped through finite element analysis. In conclusion, square threads exhibited the most favourable outcome.[9] Eraslan et al. (2009)[10] evaluated the result of thread geometry on stress dissipation in an implant. Four different implant thread-form configurations were assembled with the adjacent structure of bone. Buttress, reverse buttress, V-thread and square thread designs were reproduced. 100N fixed axial occlusal load was put vertically over the surface of the abutment to determine the dissipation of stress. The von Mises stress values showed that highest stress applications were detected at the loading areas of the implant abutments as well as for all models at the cervical cortical bone region. The current investigation presents that the application of three dissimilar thread geometry did not influence the von Mises concentration at adjacent bone form. The compressive stress concentrations however varied by varying thread profiles.

Dhatrak et al. (2017)[11] evaluated the Stress dissipation of implants around Implant-Bone Interface. Square, v thread and buttress thread profiles were used in the study. 300N of the static load was applied to the top of the abutment to figure out the shear stress around the implant and bone region. The maximum value of stress is found in the model containing the reverse buttress thread profile around the apical part of the implant while minimum value was detected in the implant with V thread profile at the critical region, and is proved as the most superior thread design amidst the rest two within greatest shear stress criteria.

Nam et al. (2015)[12] investigated the Stress dissipation characteristics of four implant thread designs with the force of 100 N was applied onto the top of implant abutment at 30 degrees with the implant axis. To mimic different osseointegration stages at the implant/bone interfaces, a nonlinear contact condition was used to imitate immature osseointegration and a bonding condition for mature osseointegration states. He concluded that Stress dissipation characteristics of the V-shape thread were in the middle of the four threads in both the immature and mature stages of osseointegration. This systematic review was an attempt to find the best available evidence to determine which implant thread design distributes the least force on the surrounding bone. However, it is difficult to conclude the articles selected as they cannot be compared directly due to the diversity of eligibility criteria's, assessment methods and outcomes.

CONCLUSION

The implant thread geometry is a major factor in the biomechanical properties of dental implants as they improve primary contact, enhance surface area and aids in the distribution of stresses at the interface of bone-implant. Various studies have been conducted to compare the distribution of forces on the bone by the different implant thread designs. Some studies claimed square thread design as best while some claimed V-shaped. It is difficult to draw a conclusion relating to the eligibility criteria and as the studies don't show a significant difference in the results obtained for comparison. The stress distribution pattern was not affected by the different usage of implant thread geometry and varying osseointegration conditions. More studies are required with a bigger sample size as it is difficult to conclude at this stage.

Studies with larger sample size and long term follow up; studies about all different kinds of thread designs in the same sample may be carried out to evaluate which amongst the different implant thread designs has the least value of stress on both cortical and cancellous bones.

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REFERENCES

1. Kulkarni SP, Bulbule SN, Kakade MD, Hakepatil VN. Radiographic Stents and Surgical Stents in Implant Placements: An Overview. Int J Curr Res Rev 2019;11(12):11-15.
2. English C. Dental Implant Prosthetics Carl E. Misch Implant Dent 2005;14(1):11-12.
3. Brunski J. In Vivo Bone Response to Biomechanical Loading at the Bone/Dental-Implant Interface. Adv Dental Res 1999;13(1): 99-119.
4. Geng JP. A differential mathematical model to evaluate side-surface of an Archimede implant. Shanghai Shengwu Gongcheng Yixue 1995;50:19
5. Geng J, Ma Q, Xu W, Tan K, Liu G. Finite element analysis of four thread-form configurations in a stepped screw implant. J Oral Rehab 2004;31(3):233-239.
6. Ivanoff C, Grönhahl K, Sennerby L, Bergström C, Lekholm U. Influence of variations in implant diameters: a 3- to 5-year retrospective clinical report. Int J Oral Maxillofacial Impl 1999;14:173–180.
7. Van Oosterwyck H, Duyck J, Vander Sloten J, Van der Perre G, De Coomans M, Lieven S et al. The influence of bone mechanical properties and implant fixation upon bone loading around oral implants. Clin Oral Impl Res 1998;9(6):407-418.
8. Oswal M, Amasi U, Oswal M, Bhagat A. Influence of three different implant thread designs on stress distribution: A three-dimensional finite element analysis. J Indian Prosthodontic Soc 2016;16(4):359.
9. Mosavar A, Ziaei A, Kadkhodaei M. The Effect of Implant Thread Design on Stress Distribution in Anisotropic Bone with Different Osseointegration Conditions: A Finite Element Analysis. Int J Oral Maxillofac Impl 2015;30(6):1317-1326.
10. Eraslan O, İnan Ö. The effect of thread design on stress distribution in a solid screw implant: a 3D finite element analysis. Clin. Oral Invest. 2009;14(4):411-416.
11. Hatrak P, Shirsat U, Sumanth S, Deshmukh V. Finite Element Analysis and Experimental Investigations on Stress Distribution of Dental Implants around Implant-Bone Interface. Materials Today: Proceedings 2018;5(2):5641-5648.
12. Nam O, Yu W, Kyung H. Stress dissipation characteristics of four implant thread designs evaluated by 3D finite element modeling. J Kor Acad Prosthodont 2015;53(2):120.