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A Review on Platform-Switching Concept on Stress-Distribution Pattern of Different Dental Implant-System

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BACKGROUND:
The platform switching concept involves the reduction of the restoration abutment diameter with respect to diameter of dental implant. Long –term follow up around these wide-platforms showed higher level of bone preservation and proper stress distribution and esthetic look.
AIM:
The aim of this paper is to carry out literature review of studies which deal with the influence of platform-switched implants in hard and soft tissue with Finite element method and stress distribution pattern observed in different implant systems.
MATERIALS AND METHOD:
All papers involving Dental implants, Platform-switching, Finite element analysis and combination of these words where used and papers from science direct, ELSEVIER, Pub Med were analyzed and reviewed.
RESULTS:
In our search most of papers result outcome indicate that in platform-switching peri-implant bone resorption is reduced and showed better stress distribution around bone than conventional implants system.
CONCLUSION:
All papers written by different researchers showed an improvement in peri-implant bone preservation and better stress distribution and less stress transfer to bone. However there is lack of non-linear finite element analysis which would explain real life simulation and better stress-distribution pattern and experimental methods to validate this results which are to further needed to be develop.

Keywords: - Dental implant, Platform-switching, stress analysis. FEA.

1. INTRODUCTION

A dental implant is artificial tooth that is placed into jaw bone to replace missing teeth which might be lost due to periodontal injuries or accident or some other reasons. Dental implant system as shown in Fig 1 consist of crown which replaces missing tooth , Implant which acts as anchors in bone, abutment on which crown fits , screw which connects implant and abutment. But now days patients receiving implant treatment not only expect restoration of masticatory function, they also expect it to be esthetically pleasing, easy to clean and permanent. For which long term stability is necessary which depends primarily on nature related to bone quality at the implant site which is responsible for implant osseointergration and secondly healing time and stability given by newly formed bone [18]. The bone loss of around 2mm is generally regarded as successful of implantation [19]. The higher occlusal load coming on prosthetics element causes the crestal bone loss around the implant which leads to failure and generation of higher stresses at implant-bone interface leading to sever pain and bleeding.

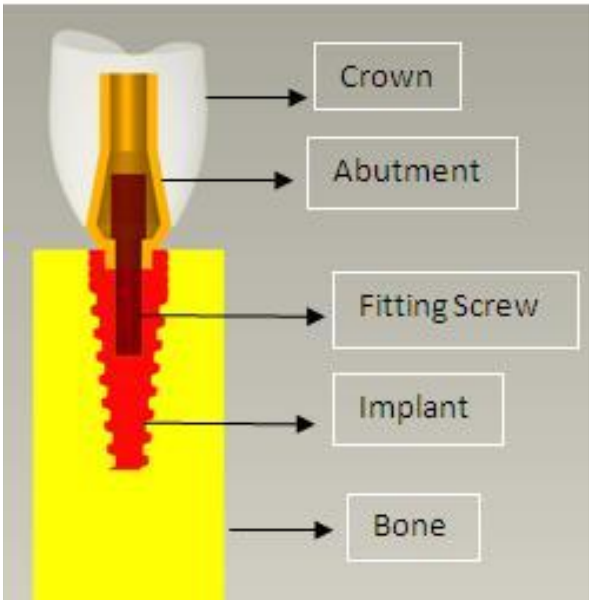

Figure 1 Dental Implant System

In this review paper we tried to collect various studies on stress analysis of platform switching technique in dental implant with description of various parameters like loading condition, effect of abutment diameter, type of connection etc. The objective of this paper will be helpful as guidelines and more correct way to perform research work.

2. MATERIALS AND METHOD

In this paper we review literature dealing with impact of platform switching in implants and impact on stress distribution, finite element analysis, and photo elasticity. Search was carried out using science direct, pubmed search engine with keywords platform switching, finite elements analysis, stress distribution, dental implant. Over 50 papers where found published between years 2007-2015 and of which 19 papers which mainly deals on FEA analysis were on keen interest where short listed and reviewed. 2 papers included in this review paper where literature survey conducted previous by some authors and 2 papers containing photo elasticity experimental method to validate stresses in platform switching implants. Most studies included linear properties for cortical, cancellous bones and implant with 100% osseointegration and micro movement between components was not considered.

2. PLATFORM SWITCHING

There are numerous parameters which affect the preservation of priimplant marginal bone loss. One of which is platform switching introduced in mid-1980's .As use of conventional implant abutment systems are generally flush with implant shoulder which results into micro crack between implant and abutment due to stress exceeding yield strength leading to failure of system. This problem is overcome in platform switching with use of mismatch diameter of abutment. Generally abutment of smaller diameter is used with implant providing platform at neck. Due to use of platform switching there are (1) inward movement of the IAJ (implant abutment junction) is believed to shift the inflammatory towards the central axis of implant and away from adjacent crestalbone. Which ultimately leads to stress concentration within abutment and implant (2) connective tissue thickness laterally which increases blood flow around that area ; and (3) ICT(inflammatory connective tissue) is confined above the level of implant platform. These bones around the implant shoulder from ICT. As result biological width does not decrease in order to cover up the ICT and such there is no crestal bone loss [2].

3. DISSCUSION

C.Cumbo et al [1] carried out literature review of studies which deals with influence of platform-switched implants in hard and soft oral tissues. In which clinical cases, experimental and finite elements analysis where included. Clinical case included in his research by various authors agreed with fact that firstly, bone lost observed during first month after implantation where lower in case of platform switched implants less then 2mm and even showed better esthetics compared to conventional implant system. In his review he concluded platform switching improves bones crest preservation and leads to controlled biological space reposition.

Maeda et al [2] carried out 3D finite element analysis for single implant-retained for mandibular region. In which he examined biomechanical advantages of platform switching and concluded platform switching shifts the stress concentration away from implant-bone interface, but these forces are then increased in abutment and abutment screw.

Hst JT et al [3] carried bone strain and interfacial sliding analyses of platform switched implant using FEA and experiment where his results showed 10% decrease in all prosthetic loading forces transmitted to bone implant interface.

Yoshiyuki Hagiwar et al [4] carried literature survey , whether platform switching really prevent crestal bone loss around implants or not. His work included various factors such as occlusal overloading, biological width, micro-gap, implant crest module effecting crestal bone loss around implants. He also studied what is effect of platform switching technique on prevention of bone loss which included finite element analysis with five FEA cases most of them favoring platform switching, nine reports on humans having conventional and platform switched implants for same patients and animal studies for 2 dogs. However platform switching showed positive effect Yoshiyuki Hagiwar concluded that further studies, including histological studies using animals should be conducted to clarify full mechanism.

Canay S et al [5] carried 3-D FEA for bone-level diameter shifting at implant-abutment interface for 8 different models of Ankylos implants with platform switching with tapper joint for vertical loading conditions. His work concluded that effective factors on mechanical properties of implant/abutment complex rather than stress distribution in crestal bone.

XIA Haibin et al [6] compared stress distribution between platform-switched and non platform-switched implants for single supported teeth for surrounding bone, abutment and screw for 6 different loading conditions such as lingually, buccally, distally and combinations of these with vertical and oblique action. The result showed that both case did not differ much but platform switching had advantage of reducing von misses stress within surrounding bone.

Angel Alvarez-Arenal et al [7] did 3-D linear finite element to evaluate and compare stresses in abutment and retention screw for conventional and platform switched implants for vertical and oblique loading of 15, 30 and 45 degrees. Results showed for axial loading von mises stresses for conventional model where lower than platform switched model and as obliquity increased the stress also went on increasing in both models. Maximum stress distributed was observed at the margin and transgingival area of abutment and on two-third of the flat area and around first thread of retention screw. He concluded that whether platform switching concept was employed or not the stress on components increased as there is increase in angle of load application.

Jason Schrotenboer et al [8] investigated using 2-D linear FEA effect of micro threads at implant collar and smooth neck for same tapered implant dimension and 3three different abutment diameters with vertical and oblique force at 15 degree and analyzed stress pattern. Results showed that micro thread model had greater stresses in vertical and oblique loading however when reduce diameter abutments were used micro threaded model showed 6.3 % to 5.4 % reduction in stresses for vertical loading 4.2% to 3.3 % reduction in stresses under oblique loading. On other hand smooth model showed 5.6 % to 4.9 % reduction in stresses for vertical and 3.7% to 2.9 % reduction in stress for oblique loading. He concluded that when concept of platform switching was applied less stress where transferred to crestal bone in both models.

Mahasti Sahabi et al [9] determined influence of platform switching on stress distribution for Xive and 3i system containing each of three models having one platform switched model for Xive and 3i system having 2 platform switched model. He observed that stress distribution was similar for both loading situations, oblique loading resulted in higher intensity and greater distribution of stress than axial loading in cortical and implant-bone interface, with all models having almost identical stress distribution at per implant system. However platform switched model demonstrated lower maximum von mises stress at cortical bone. He concluded platform switching design reduced the stress concentration in crestal bone and shifted towards area of implant abutment interface.

Luigi Canullo et al [10] carried 3-D FEA experiment for standard (SD) , platform switched (experimental design, ED) and wider platform switched implant (WCD) system for horizontal and vertical load and evaluated von mises stresses. Results showed substantial decrease in stress at the threaded implant region due to diameter mismatch between implant and abutment for ED configuration. He concluded that there was notable stress field shift from bone towards the implant system, potential resulting in lower crestal bone overloading.

Roberto S.Pessoa et al [11] evaluated biomechanical parameters such as peak equivalent strain(EQV strain) in bone, bone to relative implant displacement , peak von mises stress (EQV stress) for various conditions immediately loaded, immediately placed and osseointergrated protocol for external hex implants with conventional and platform switched implants. Frictional contact between bone-to-implant and implant component interface were included. Results showed that highest EQV strain for bone and for implant displacement was for immediately placed then followed by immediately loaded and then by osseointegrated. No statistically significance influence of abutment diameter on biomechanical parameters expect for bone to implant displacement which was very low. He concluded that mismatch of 0.5 mm does not make any important contribution to biomechanical parameters.

Stefano Sivolella et al [12] carried 3-D FEA for wide-diameter external hex implants having matching and narrow abutment for vertical and off center loading condition and models with different bone properties i.e. modulus of elasticity. Results showed in symmetrically loaded models, greater stresses were transmitted to bone in area below the neck of the implant in the case of the wider diameter abutment however in case of narrow abutment stress lines remained confined to metal and were transferred to bone in a more distal position. For non symmetrical loading stress were lowered in off centre loading, however in case of bones with different properties stress where greater in model having higher modulus of elasticity.

Amilcar C. Freitas-Junior et al [13] studied effect of abutment's diameter on reliability and stress distribution for internal and external hexagon platform switched implant-abutment connections. He's study included vitro and 3-D FEA analysis which included 84 implant distributed into four group n=21 with various configuration as platform switched with internal and external hexagon(SWT-IH, SWT-EH) and regular platform with internal and external hexagon (REG-IH,REG-EH). In vitro study he carried out single-load-to-fracture (SLF) and determined three step stress accelerated-life testing profiles for 18 specimens assigned into moderate , mild and aggressive subjected to constant stress during a predetermined length of time. Based upon the step-stress distribution of failures, the fatigue data were analyzed using a power law relationship for damage accumulation and the use level probability weibull curves. Result for step stress accelerated life testing showed higher reliability for SWT-IH, REG-IH implants. In FEA study he considered four models representing each configuration obtained stress distribution. Results obtained showed strong influence of abutment diameter on stress distribution. When reducing abutment diameter, an increase in stress was 41.08% for external hex implant (SWT-EH) while increase in stress of 53.27% was observed for (SWT-IH).He concluded that platform-switched implants increased stress concentration within implant abutment connection leading to lower reliability.

Siyu Liu et al [14] carried non-linear FEA for commercial Ankylos having platform switching concept and Anthogyr having convention system for mandabile molar region. Analysis included non linear frictional contact to be 0.65 for implant/cortical bone interface, 0.77 for implant/cancellous bone interface and 0.3 for titanium/titanium with horizontal and vertical load application on occlusal surface of abutment on half of surface due to symmetry. Results indicated stresses inside the implant in both models are concentrated at abutment neck and in connection section where the abutment inserts into implant for horizontal loading. Von mises stress where higher in platform switched implant. The maximum von mises stresses transfer to cortical bone where lower in platform switched case. However he concluded platform switching configuration reduced stress concentration on peri implant cortical bone also there exists risk of implant facture.

Marco Aurelio Carvalho et al [15] carried non-linear FEA analysis having nine different models having platform switching with external, internal and Morse tapered and 3 different materials for abutment i.e titanium (Ti), zirconia (Zr) and hybrid(Hs) with various configurations for oblique loading of 45 degrees relative to implant long axis. Highest abutment stress occurred in morse-tapered group and lowest in external hexagon-hybrid followed by internal hexagon-titanium and internal hexagon-hybrid group. He concluded that H abutments presented similar mechanical behavior to Ti abutment and better mechanical behavior than Zr abutments.

Eduardo Piza Pellizzer et al [16] evaluated stress distribution using photo elasticity method for 1 platform switched model, conventional model and wider-diamter model . For which implant was inserted into resin with torque of 20N and load was applied axial and oblique on crown surface. Each implant was arbitrarily divided into 3 zones as coronal, middle and apical. The fringe pattern indicated the amount of stress. For axial load platform switched model had less number of fringes, on other hand oblique loading also indicated less number of fringes for platform switched model showing stress concentration decreased in the cervical region. Platform switching and wider-diameter displayed similar stress magnitude.

Fabiana Rossi et al[17] evaluated stress distribution using photo elasticity method in cervical and apical site of implant-abutment interface of conventional (external hex, internal hex and cone morse) implant site and compared them with novel platform switching. Qualitative results indicated less concentration of strain in cervical area of internal hex and platform switching. Same results were observed of quantitative analysis. Concluding that platform switching prevents bone loss.

Sabet Marwa et al [20] measured strain developed around platform switched implant having abutment sizes 5.5mm, 4.5mm, 3.5mm fixed in acrylic model for canine area with 2 implant fixtures. On application of load 100N axial, anterior off-axis (lateral) and posterior on each abutment using universal testing machine and recording using 4 strain guage connected to 4-channel strain indicator and analyzed data by 1-way ANVO at significance level of 0.5 followed by tukey-kramer multiple comparisons test. Results indicated for axial loading decrease abutment size leads to decrease in strain developed on loaded abutment. For anterior off-axis load application and decreasing abutment size lead to an increase in the strain developed on loaded abutment on other hand posterior load application decrease in abutment size leads to increase in strain on mesial side of near abutment. However conclusion decrease the abutment size did not favor the use of platform switching.

Tabat et al [21] with aim to evaluate biomechanical concept of platform switching with relation to stress distribution carried 2-D FEA analysis. Work included 2 models of implant i.e regular with platform 4.1mm and wider 5.0mm connected to abutment of 4.1mm diameter. Stresses of 159Mpa and 1610Mpa where observed for regular platform model for periimplant and implant region, on other hand 34Mpa and 649Mpa stresses where observed in periimplant and implant for wider platform case. Conclusion showed that platform switching showed better biomechanical behavior for stress but stress concentration was increased in crown, retention screw.

4. RESULTS

The results describe by various authors are in favor. The stress distribution in all platform switched implant showed less stress in bone around implant due to which bone lost around implant is lower than conventional implant system and even better aesthetics. The principle aspect of consulted articles refers to biomechanical behavior of implant abutment complex in response to occlusal loading, bone crest level preservation.

5. CONCLUSIONS

On reviewing all literature it's concluded that platform switching is capable of reducing crestal bone loss as stresses observed in most of case for periimplant region were lower compared to conventional systems. However FEA has proven valuable tool in assisting biomechanical performance of implant as many studies can be carried out with simulation without going for actual clinical studies. Though FEA is valuable and time saving tool there is also need to develop experimental methods like photoelasticity, strain gauges etc which can be helpful to validate results. Nonlinear FEA should be carried out to simulate more real life situation which would give more accurate results.

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