Implant Fracture: A Review Article

Dr .Vijay Ebenezer[1], Dr. G. Sumathy [1*] Dr. R. Balakrishnan[2]

[1]Research scholar, BIHER ,SBDCH Professor & HOD, Department of Oral and Maxillofacial Surgery, Sree Balaji Dental College and Hospital, BIHER, Chennai- 600100, Tamil Nadu, India)

[2]Professor, Department of Oral and Maxillofacial Surgery, Sree Balaji Dental College and Hospital, BIHER, Chennai- 600100, Tamil Nadu, India)

[1*] Supervisor ,Dept of anatomy, Sree Balaji Dental College and Hospital, BIHER, Chennai- 600100, Tamil Nadu, India.

Abstract: Dental implants have become a revolutionary means of rehabilitation for edentulous and partially edentulous patients, and successful integration of has been well documented for patients with those clinical conditions. Since the rate of success in edentulous case has been high, the concept of osseointegration has become a predictable treatment modality [2]. Yet this now gold standard treatment modality is not without its own set of adversities. Implant failures are almost as common as implant success. The types of implant failures are 1) loss of integration, 2) positional failures 3) soft tissue defects, and 4) biomechanical failures. In this article we shall delve deeper into the failure due to implant fracture aspect.

Keywords: Dental implant, screw breakage, implant fatigue, biomechanical failure of dental implants, dental implant failure. Dental implant fate, fatigue of dental prosthesis, stress induced fatigue in implants.

INTRODUCTION

Within the past few decades dental implants have progressed a lot from being the implants used and studied by Dr. P. Brånemark in 1978. He was the 1st person to observe and thus describe the concept of osseointegration, although the true credit of 1st ever dental implant to be used in recorded human history goes to the ancient Mayan civilization in 600AD, where they successfully implanted pieces of shell as replacement for mandibular teeth. Scores of physicians, scientists and dentists have over the centuries helped to make dental implantology as it is today, a very reliable rehabilitation method for edentulous spaces in both the maxilla and mandible. Implants vary immensely according to the shape as well as the composition as well as with an internal hex or external hex design. Modern implants that are commonly used are mostly root form and are generally torqued into place after the drilling has been done into the bone. The steps involved in implant placement are: (1) proper treatment planning and selection of implant dimensions for the tooth to be replaced, using radiographic interpretation of dimensions and density of the alveolar bone with clinical correlation. CB-CT is considered to be gold standard. (2) Surgical phase, where first a surgical guide is placed, pilot drill is then used with a slow rotation physio-dispenser to drill up to the required depth which is equal to length of implant. The consequent drills of increasing diameter are used to reach desired diameter. The implant is then tightened into place using a torque wrench and a Hex. The maximum torque recommended for root form implants is 75 Nm. The sweet spot is around 30 Nm. The healing cap is then screwed in. Then the surgical site is closed and hence commences the healing phase. The healing phases is generally 3 months for mandible and 6 months for maxilla. This enables oseointegration to happen. (3) Prosthetic phase, where the site is opened up, over lying bone is removed if necessary, the healing cap is removed and an abutment is screwed in and impression is taken for cast pouring. Then, the prosthesis is fabricated and fixed on the abutment.Yet this golden standard of rehabilitation for edentulous spaces, although so refined, has immense potential for failures as well. As many cases fail as the number of successful cases. Research over the years have shown that the major causes of implant failure are (a) deficient osseointegration, (b) complication of the neighboring soft tissues (peri-mucositis and periimplantitis) and (c) mechanical complications. Among the biomechanical problems, screw loosening, abutment rotation, and abutment fracture are the major issues [2]. We shall now go into more details about abutment fractures and the physical factors that resist as well as cause it.

DISCUSSION

Micro Metal fatigue of restorative materials can lead to breakage — the rigid connection of implants bone demands that attention is paid to the size of connectors[1]. Fracture of implants and implant components can happen often and this is due to improper treatment planning and excessive forces being exerted on the implants. Example of an improper treatment plan is- a single implant in an incomplete dentition and a terminal tooth, the implant being connected to the tooth causing decay on the tooth, and eventually the implant to fracture under the load. Most of the materials used to restore implants are derived from conventional restorative dentistry, for example denture base resins. Complete denture wearers develop relatively little bite force compared to force generated with implant supported restorations. Breakage is a common failure of overdenture restorations.Youssef S. Al Jabbari, Raymond Fournelle, et al [8] published a study in 2007, where they performed a failure analysis on fractured prosthetic retaining screws after long-term in vivo use. The study also addresses the commonly asked question regarding whether complex repeated functional occlusal forces initiate fatigue-type cracks in prosthetic retaining screws. They did the study on ten fractured implants from 3 patients. In two patients, the middle three retaining screws of the prostheses were found fractured at the time of retrieval. They were in service for 20 and 19 months, respectively. In the last patient, the middle three retaining screws and one of the posterior retaining screws were fractured at the time of retrieval after they had been in use for 18 months. Low power stereomicroscopy and high-power scanning electron microscopy (SEM) were done to analyze the fractured surfaces of the retaining screws to examine fatigue cracks in greater detail.Roman M. Cibirka, Steven K. Nelson, et al d [7] id a study to examine potential differences in detorque values of abutment screws after fatigue testing when the dimensions between external implant hexagon and internal abutment hexagon were altered or the implant external hexagonal shape was eliminated. Ten NobelBiocare implants were divided into 3 groups and assessed: (1) standard external hexagon (R), (2) modified hexagon (M), and (3) circular (C) platform geometry. Thirty Procera machined abutments with 25-degree angulated loading platforms were manufactured. Abutments were retained with gold Unigrip abutment screws tightened to 32 N/cm with an electronic torque controller. Vertical scribes across the implant–abutment interface allowed longitudinal displacement evaluation. A carousel-type fatigue testing device delivered dynamic loading forces between 20 and 200 N for 5,000,000 cycles, or the approximate equivalent of 5 years in vivo mastication, through a piston to the abutment platform. Macroscopic and radiographic examination of the implant/abutment specimens was performed. The abutment screws were removed and the detorque values recorded. Bearing surfaces were examined microscopically. No abutment looseness or longitudinal displacements at the implant–abutment interface was noted. Radiographic examination demonstrated no indication of screw bending or displacement. The mean detorque values for R, M, and C were 14.40 ± 1.84 N/cm, 14.70 ± 1.89 N/cm, and 16.40 ± 2.17 N/cm, respectively. They concluded that Increasing the vertical height, or degree of fit tolerance, between the implant external hexagon and the abutment internal hexagon or completely eliminating the implant external hexagon did not produce a significant effect on the detorque values of the abutment screws after 5,000,000 cycles in fatigue testing, or the equivalent of 5 years' of mastication for the implant/abutment specimens evaluated. All of the middle three retaining screws from each group and one of the two posterior screws were fractured with moderate to severe thread wear. All the fractured screws showed rachet mark defect on the fracture surfaces, which Shows typical fatigue failure. SEM examination revealed all three classical stages of fatigue failure, and it was possible to see the ratchet marks on the fracture surfaces of all specimens, indicating a fatigue zone. The final catastrophic overload fracture appeared fibrous, indicating ductile fracture. The final overload ductile fracture surfaces showed equiaxed dimples, suggesting tensile overload in all examined screws except in two specimens that showed an elongated dimple pattern indicating shear/tearing overload forces. They thus concluded that Fracture of prosthetic retaining screws in hybrid prostheses occurs mainly through a typical fatigue mode involving mostly the middle anterior three screws. Fatigue cracks can grow in more than one prosthetic retaining screw, leading to fracture before the patient or clinician determines that any problem exists. In 2015, Sun-Young Lee, Sung-Jun Kim, Hyun-Wook An, *et al* from Institute of Science & Technology, Megagen Implant, Gyeongsan, Republic of Korea Department of Periodontology, School of Dentistry, Kyungpook National University, Daegu, Republic of Korea MIR Dental Hospital, Daegu, Republic of Korea conducted a study to determine the effect on mechanical properties due to thread depth of various lengths of dental implants.The researchers used Commercial Titanium implants of various lengths, diameters and thread depths and Solid rigid polyurethane blocks with uniformity as an alternative to human cancellous bone. The implants were tightened with a recommended torque of 30 Ncm using a digital torque meter. [3] The Titanium implants were tightened with the EZ Post containing the hemispherical loading members were fixed with a specimen holder that was made from brass and clamped in the jig of a universal test machine [3]. After the static compressive strength tests, the Titanium implants were examined macroscopically. The failure mode was observed to be deformation in the abutment and being torn horizontally at the upper side of the Titanium implant. The threads in the Titanium implants with deeper threads did not show breakage. Titanium implants with the same length and inner diameter have a similar maximum compressive strength. The mechanical strength is more related to the length and diameter than the thread depth. The failure mode was observed in the fixtures and abutments but not the threads. The thread depth did not have a major effect on the mechanical strength. Titanium implants with deeper threads did not induce the breakage of threads applying the maximum compressive strength. Dental implants may fracture at load levels below the maximum compressive strength of the implant/abutment complex. Thus, the maximum compressive strength may suggest a standard point of acute overload. Mechanical failures of dental implants appear through a repeated loading process at low loads. The fatigue test is a general method used in the laboratory to mimic actual intraoral use. The fatigue limits of the dental implants with a diameter of 4.0 mm and thread depth of 0.6 mm (636 N) and those with a diameter of 4.0 mm and thread depth of 0.35 mm (619 N) in the fatigue test on the basis of the International Organization for Standardization (ISO14801) were both more than 600 N. The fatigue limit of the Ti implants with deeper threads is similar to that of Ti implants with shallow thread depth. The study indicated that the Ti implants with the deeper threads have similar mechanical stability [3]. In 2009, Cleide Gisele RIBEIRO, Maria Luiza Cabral MAIA, Susanne S. SCHERRER, *et al* from Brazil conducted a study on the fatigue resistance of dental implants based on the design of abutment-implant interface. This study demonstrated the superior fatigue resistance of external hex interface. There was no significant difference between the conical and internal hex interfaces. Probably, the quality of the surface machining of the flat-to-flat mating surfaces (mainly, the machining accuracy of the screw and thread) determined the superior resistance of the connector; The mode and region of fracture in prosthetic screws observed in this study suggested that failure of these screws occurred by fatigue (presence of fatigue striations) and involved the threaded part [2]. Ana I. Nicolas-Silvente, Eugenio Velasco-Ortega, et al [6] did a study, where fifty-four titanium dental implants from three different implant systems were compared in this study. The characteristics of each implant group are summarized: - Group I (n = 19): Surgimplant CE: titanium grade 5 dental implant with hexagon external connection (platform: 3.5 mm, length: 12 mm) (Galimplant SLU, Sarria, Lugo, Spain) - Group II (n = 18): Surgimplant CI Double Hexagon: titanium grade 5 dental implant with double hexagon internal connection (platform: 3.5 mm, length: 12 mm) (Galimplant SLU, Sarria, Lugo, Spain) - Group III (n = 17): Surgimplant CI Octagonal: titanium grade 5 dental implant with octagonal internal connection (platform: 4.0 mm, length: 12 mm) (Galimplant SLU, Sarria, Lugo, Spain). A fatigue test was performed to obtain the number of cycles before fracture. The maximum and minimum force applied was recorded for each sample. The assays were performed with a servo-hydraulic testing machine (MTS 858 Mini Bionix II, MTS, Minneapolis, MN, USA) equipped with a load cell MTS 661.19F-01 of 5 kN. The implants were fixed 30 angulated with the axis z of the load cell. Maximum loading applied to the implant was around 80% of the value of the implant failure load, obtained by a static test under the same geometric conditions as fatigue tests, following ISO 14801:2008 recommendations. All tests were carried out under stable environmental conditions with a temperature of 25 C and relative humidity of 60%. The failure mode was similar in all experimental groups, including large deformations at the implant neck area. The implant neck fracture took place most of the cases between the first and second threads. The authors concluded that the platform diameter a ects the fatigue load limit, obtaining a lower fatigue load limit implants with the narrow platform (3.5 mm) than the regular platform (4 mm). On the other hand, the indexation design may interfere with the width of the implant walls, especially in narrow implants, making internal connections more unstable at this level. It would be advisable to develop long-term clinical studies to assess the restoration's success rate and survival. Thus, implants are not without such chance of failure. Studies conducted has yielded results that around 10% of implants result in failure. Out of that around 2% is due to implant fracture. Implant fracture generally occurs due to faulty manufacturing, improper abutment, due to trauma from occlusion due to improper height or due to patient related cause such as biting an extremely hard object like walnut or very hard bone. Out of all these manufacturing defects is of the least incidence. Patient induced fracture is the most common.

CONCLUSION

SO, we can now conclude that even though implants are considered the gold standard now, failures are pretty common and the possibility of an implant fracture is dependent on a multitude of various factors such as technique, material, design and the peri-implant environment as well. Since titanium implants are so very much biocompatible, they can be left as it is, without any complications, if a fracture does occur and it is not feasible to remove the fractured implant.

CONFLICT OF INTEREST

Conflict of interest declared none.

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