Osseointegration for Dental Implants : An Overview

Jayanthi Dharmapalan*, Nasiha Fathima Zaheer, Abha Karanjkar**, Prathima Bommineni**, Parth Pratim Roy****

* Professor, ** Postgraduate student, Department of Periodontology, M. R. Ambedkar Dental College, Bangalore, India.

Abstracts: On-going research will allow discrimination between those systems that really osseointegrate predictably and those that do this irregularly. Long term maintenance of dental implants is gaining importance as the main factor affecting the long term prognosis of dental implants. Patients should be well instructed in maintaining oral hygiene around the dental implants. A lot of implant cleansing aids are more widely available in line with the growing demand of dental implants. The presence of attached gingiva is being recognised as important for the maintenance of good oral hygiene in reducing the incidence of periodontal disease around the implants. [Nasiha F et al NJIRM 2015; 6(3):105-112]

Key Words: Amalgam, radiation, needle prick, awareness, biomedical waste.

Author for correspondence: Dr. Nasiha Fathima Zaheer, Postgraduate student, Department of Periodontology, M. R. Ambedkar Dental College, Bangalore, India. Email: drnasihazaheer@gmail.com

Introduction: The word osseointegration consists of "os"- the latin word for bone and "integration" - latin word meaning the state of being combined into a complete whole. The phenomenon of Osseointegration was discovered by Dr. Per Ingvar *Branemark* et al in *1952* . Before osseointegration, the permanent attachment of bone anchored amputation prosthesis to bone was not possible. Early attempts failed because of the formation of fibrous tissue between the implant and bone. Dr. Per Ingvar Branemark, Professor at the institute for Applied Biotechnology, University of Goteborg, Sweden, discovered a direct, strong bone anchorage of titanium chamber while studying microcirculation in bone repair mechanism. Dr. Per Ingvar Branemark was conducting studies regarding vascularity of bone marrow in rabbit fibula. Branemark, to his surprise found that titanium chamber was bonded to the bone and the two had become inseparable. He also founded that on application of force, a fracture always occurred in bone, and never between bone and titanium.

Many studies followed, involving titanium implants being placed into jaws of dogs. Anchorage capacity of the integrated Implants was shown by suspending the Dog through wires Connected to the fixtures. Direct bone anchorage was shown to be very strong. A force of over 100kg was applied to dislodge an implant.[1] Based on such a consequence the foundation for Osseointegration and the Branemark implant system was established in 1952. Studies on humans were conducted by means of an implant optical titanium chamber in a twin pedicle skin tube on the inside of the left upper arm of volunteers. Tissue reactions were studied in long term experiments.[1] All this lead to the establishment of Branemark clinic for osseointegration implant treatment at Goteburg university and treatment of first edentulous patient in 1965.American Academy of Implant Dentistry defined Osseointegration as "contact established without interposition of non-bone tissue between normal remodelled bone and on implant entailing a sustained transfer and distribution of load from the implant to and within bone tissue". Primary osseointegration is dependent on Initial wound healing that is assured through maintenance of a non-mobile contact between the osteotomy and the implant. Secondary osseointegration is dependent on the pattern of replacement of initial bone contact with mature load carrying bone around the implant surface.

Bone Biology And Osseointegration

Quality of host bone : Biological fixation between a titanium implant and host bone depends upon the quality and architecture of the supporting bone used in the procedure.[2]The human skeleton is comprised of approximately 80% cortical bone and 20% cancellous bone; however, the ratio between these bone types varies greatly between anatomical locations. bone formation at the periprosthetic interface has shown to be a slow but a dynamic and tightly coupled process[3]coordinated between cells,[4]hormones,[5]and enzymes.[3]Modeling and remodelling of bone tissue around an OI implant results from complex chemical interactions and mechanical stimuli.

It has been largely accepted that bone adapts to mechanical loads in accordance with Wolff's law.[6] The functional adaption of bone, most studied in the proximal femur, demonstrates the unique ability of bone to alter its trabecular orientation as a result of loading conditions.[7]Bone quality is classified into 4 types. Type I bone is comprised of homogenous, compact bone throughout the entire jaw, Type II bone has a core of dense trabecular bone surrounded by a thick layer of compact bone, Type III bone has only a thin layer of cortical bone surrounding a core of dense trabecular bone, and Type IV bone a core of low-density trabecular bone of poor strength encased in thin cortical bone. Using the above hierarchy, Type I and II promise more successful implants.[8]

Surgical site preparation/implant stability: While proper instrumentation and operative techniques help to minimize disturbance to the localized vascular network during osseointegration procedures, uncontrolled thermal or mechanical factors (reaming, rasping, or drilling) used to ensure proper implant "fit and fill" or fixation may damage the host bone's ability to remodel. Gaps in excess of 50–150 µm between the implant surface texture and host bone may lead to fibrous tissue without skeletal attachment.[9] To improve the likelihood for dental implant survivorship, novel techniques have been developed that use computed tomography scans from the patient's mouth, and computer-aided design.[10] Trauma to the host bone tissue during surgery may also accelerate local bone turnover. This has been termed the "regional acceleratory phenomenon" (RAP), which was first defined by Frost, using noxious stimuli, and then by Bloebaum et al. The RAP may occur for two reasons: the first being that placement of an intramedullary OI implant alters the dynamic strains to the host bone tissue.[11] Depending on the "fit and fill," the implant may result in high concentrations of localized stress or "stress shielding; "second, the surgical procedure itself disrupts the blood supply to the endosteal wall (which results in a local tissue response to re-establish bone vascularity) – thus causing an increase in cortical bone porosity. This increased vascular network is optimal for bone remodelling but will impact overall strength.[12]

The implant surface: Various metals, ceramics, and biostable polymers have been used to achieve osseointegration. The major metal types have included: cobalt chromium,[13]tantalum,[14]stainless steel, zirconium and commercial pure titanium[15] and its alloys. However, titanium has been widely advocated as the most biocompatible material for promoting osseointegration, due to its excellent mechanical properties,[16]resistance to corrosion,[17]and its ability to develop an oxide layer on the surface (comprised of a dioxide chemical structure, TiO_2).[18] Spongy bone with less density and less hardness is not a stable base for primary fixture fixation.[19] Compact bone can provide a stable base for primary fixture fixation.[20] With primary fixation in compact bone, osseointegration in the maxilla requires a longer healing period due to the difference in spongy bone density. When the bone healing progresses well, the bone cells present in spongy bone form a high density bone along the fixture surface.[21]Osteoblastic activity in adults/elderly is normally in a stage of quiescence or less active bone formation.[22] During surgical drilling procedures on these types of patients, the quiescent stage of osteoblasts changes into an active stage. These active osteoblasts produce proteins for collagen formation, a step in bone formation. To maintain a constant level of bone remodelling, there should be proper local stimulation.[23]

Loading conditions for osseointegration: Limiting the initial forces on an OI implant has been based on the principle that stress must be exerted gradually to promote firm skeletal attachment since under- or overloading may compromise the integrity of the host bone.[24] To prevent mechanical loosening at the bone–implant construct, OI procedures for dental applications initially have required periods of restricted load-bearing, to avert overloading.[25]To prevent mechanical loosening at the bone–implant construct, OI procedures for dental applications initially have required periods of restricted load-bearing, to avert overloading.[26]However, the dental and medical literature now indicates that immediate implant loading may not compromise the integrity of the bone–implant interface or prevent OI if micro motion is controlled with properly designed implants.[27]However, key design elements must be considered and include the implant neck design, screw shape, abutment design, etc during the oral implant design.

<u>*Success And Failure Of Osseointegration:*</u> Albrektsson proposed the criteria for successful integration of dental implants have been. Of these, a lack of mobility is of prime importance as 'loosening' is the most often cited reason for implant fixture removal.[28]Adell reported the success rate of 895 implant fixtures over an observational period of 5 years after placement. Eighty-one per cent of maxillary and 91% of mandibular implants remained stable.[29] Despite high success rates, implant fixture failure may occur and is defined as 'the inadequacy of the host tissue to establish or maintain osseointegration.

Factors affecting early failure of dental implants may be broadly classified as:
- implant related
-patient related
- surgical technique/environment related.

Among the above factors, the three major etiologic factors for implant failures are:

1. <u>Infection:</u> Bacterial infection that leads to implant failures can occur at any time during implant treatment. Several terms are currently used indicating failing implants or complications. These are: peri-implant disease, peri-implant mucositis, and peri-implantitis. Peri-implant disease is a collective term for inflammatory reactions in the soft tissues surrounding implants. Peri-implant mucositis is a term describing reversible inflammatory reactions in the soft tissue surrounding implants. Other soft tissue complications (hyperplasticmucositis, fistulations and mucosal abscess) seem mainly to have an infectious etiology.[30]

2. <u>Impaired healing:</u> It is believed that the magnitude of the surgical trauma (lack of irrigation and overheating), micromotion and some local and systemic characteristics of the host play a major role in implant failures related to impair healing. This can be minimized by- profuse irrigation for continuous / adequate cooling, use of well sharpened drills and use of graded series of drills. Another complicating factor is the microbial contamination, hence strict aseptic techniques should be maintained.[30]

3. <u>Overload:</u> Implant failures related to overload include those situations in which the functional load applied to the implants exceeds the capacity of the bone to withstand it. Failures that happen between abutment connection and delivery of the prosthesis, probably caused by unfavourable loading conditions or induced by the prosthetic procedure, considered to have overload aetiology. Other attributes to implant failures are poor surgical technique, poor bone quality and poor prosthesis design in addition to the traumatic loading conditions.[30]

4. <u>Other factors:</u> Ekfeldt et al.[31] identified the patient risk factors leading to multiple implant failures and concluded that a combination of several medical situations could provide a contraindication to implant treatment. Hutton et al showed that subjects with one implant failure would be likely to have others. Patient related factors include age,[32] uncontrolled Diabetes,[33] history of smoking,[34] advanced ridge resorption,[35] Osteoporosis or osteoporotic[36] like bone lesion. Stability is a requisite characteristic of osseointegration. Without it, long-term success cannot be achieved.

Material and Methods:

Methods to evaluate osseointegration are:
- Radiographic method
- resonance frequency analysis
- periotest, percusssion test
- reverse torque test
- histological
- impulse testing
- histomorphometric test
- implatest

<u>*Current Concepts In Biomaterials In Dental Implant To Increase Osseointegration*</u>

<u>Surface Treatment of Titanium Implant :</u> Previously implants had macro-irregularities like macroscopic threads, fenestrations, pores, grooves, steps, threads, or other surface irregularities that were visible. The idea was to create mechanical interlocking between implant and bone at the macro level.[37]At the microscopic level, surface irregularities are at that level, possibly in conjunction with macro-irregularities.[38] This would

afford the possibility of microscopic interlocking of bone and implant, which might enhance the load transmitting capabilities of the interface. Microscopic level involves surface coatings and modification of surface coatings and modification of surface topography to enhance bone implant integration. [39] Improvements such as the coating of the implants with bone growth factors are being actively researched in an attempt to increase the speed of implant osseointegration and to enhance the longevity of the implants.[37] Clinical studies have shown higher marginal bone levels and survival rates for blasted implant than machine turned implants .[39] Studies have presented mixed result regarding aluminium oxide left after blasting. Few authors have reported canalization of osseointegration while others have shown impaired bone formation by a possible competitive action with calciumions.[40]

Bio modification of Titanium Implant : The addition of calcium and phosphate based materials as coatings have received significant attention as these are components of natural bone. Plasma sprayed hydroxyapatite (PSHA) coating on titanium implant lead to improved maturation of newly formed bone tissue due to the high biocompatibility and osteoconduction of calcium phosphate materials and has been widely used for different hard tissue application such as hydroxyapatite (HA) coated metallic implants and bone substitute materials. HA coatings have higher success rates in maxilla (type 4 bones)where it helps to achieve primary stability as it lowers corrosion rates and enables to obtain improved bone implant attachment. However, sometimes delamination or dissolution of coating may lead to implant failure.[41]

Sputter deposition : Sputtering is a process whereby atoms or molecules of a material are ejected in a vacuum chamber by bombardment of high energy ions. Radiofrequency magnetron sputtering is a magnetically enhanced variant of diode sputtering used to deposit thin films of calcium phosphate coatings on titanium implants. Studies have shown that these coatings were more retentive, with the chemical structure being precisely controlled.[42]An outward diffusion of titanium into Halayer, forming TiO2 at the interface shows strong bonding between coating and titanium.

Antibiotic Coatings : Antibacterial coatings on the surface have been studied as a possible way to prevent surgical site infections. Gentamycin along with the layer of HA can be coated onto the implant surface which may act as a local prophylactic agent along with the systemic antibiotics in dental implant surgery. Study was done to investigate if different pH, atmosphere and surface properties could restrict bacterial adhesion to titanium surfaces used in dental implants. Titanium discs with machined or anodized (TiUnite™)surface were incubated with a co-culture of Streptococcusmitis and Actinomycesoris (early colonizers of oralsurfaces) at pH 5.0, 7.0 and 9.0 at aerobic or anaerobic atmosphere. The adhesion was analysed by counting colony forming units (CFU) on agar and by confocal laser scanning microscopy (CLSM). The results found that bacterial adhesion by S. mitis and A. oris can be restricted by acidic pH and aerobic atmosphere. The anodized surface reduced the adhesion of S. mitis compared to the machined surface; while A. oris adhered equally well to the pores of the anodized surface and to the grooves of the machined surface.[43]

Decontamination of Implant Surfaces : Tetracycline- HCl treatment has been regarded as a practical and effective chemical modality for decontamination and detoxification of contaminated implant surfaces. It also effectively removes the smear layer as well as endotoxins from the implant surface. Further, it inhibits collagenase activity, increases cell proliferation as well as attachment and bone healing. Tetracycline also enhances blood clot attachment and retention on the implant surface during the initial phase of the healing process and thus promotes osseointegration.[44]

BioinertCeramic Biomaterials : Oxide ceramics were introduced for surgical implant devices because of their inertness to biodegradation, high strength, physical characteristics such as color and minimal thermal and electrical conductivity.[45] Ceramics have been used in bulk forms, and more recently as coatings on metals. Earlier, aluminium oxide used was shown to possess high biocompatibility and microscopically highly mineralized mature compact lamellar bone with no connective tissue or inflammatory cells present at the interface. Despite its good osseointegration, it was withdrawn from the market because of its poor survival rate.

Carbon and Carbon Silicone Compounds

Carbon based biomaterials which elicits minimal host respone have also been used for ceramic like coatings onmetallic implants. In vitro study has shown better cell attachment on carbon coated zirconia than uncoated disc. Unlike metals, polymers and other ceramics, these carbonaceous materials do not suffer from fatigue. Their intrinsic brittleness and low tensile strength limits their use in major load bearing applications. However in one type of carbon blade type of dental implant, fracture loads were shown to be higher than forces expected in mastication .[46]

Polymers and Composites : Polymeric implants in the form of polymethylmethacrylate and polytetrafluoroethylene were first used in 1930s. However, low mechanical strength of polymers has precluded their use as implant materials. Combination of polymers and other categories of syntheticbiomaterials (HA, Al2 O3, Glass ceramics) have been used in porous or solid forms for tissue attachment, replacement and augmentation as coatings to transfer force to soft and hard tissue region. Biodegradable polymers such as Polyvinyl alcohol, polylactides or glycosides, cyanoacrylates or other hydrated forms have been combined with biodegradable CaPO4 for use such as structured scaffolds, plates, screws or other such applications such as bone augmentation and periimplantbone defect repairs. The use of polymers for osseointegrated implant is confined to components between prosthesis and implant for shock absorption and better simulates the biomechanical function of natural tooth function.

Discussion: *Future Development Of Dental Implantology For Improved Osseointegration:* The arrival of nanotechnology has opened new opportunities for manipulation of implant surfaces. In recent years, development of nanostructured ceramic materials like polymer Nano composites (PNC) offers an attractive path to the development of new implant materials directly from a computer model with determined shapes and porosities. However, at a more basic level, it is still not completely clear that Nano patterning will be substantially better than patterning at micron scale. High density of nanopillars has shown to create a superhydrophobic surface that can be detrimental and most of the basic studies have only been performed on flat surface.

The Growth Factors are natural proteins found in our bodies that stimulate growth of certain tissues. With respect to bone, genetic engineers have been able to isolate and clone Bone Morphogenic Proteins (BMPs), which have been shown to induce tremendous bone growth in many animal and recently human clinical studies. BMPs may very well become a potential substitute for autogenous graft material for certain applications in the future. Research in substituting the titanium material with ceramic is being pursued in order to reduce the exposure of the metallic implant body above the gingival level. This is to a certain extent being improved by the recently developed zirconium material, which is opaquely white and extremely hard and is a suitable material for the abutment construction. A material of better translucency is recently available and is composed of alumina but is considered too brittle for posterior bridge construction. There is little doubt for further search of a biological compatible material simulating the tooth colour for dental implants. We hope that this will not be too long before the opportunity of tissue engineered teeth by cell culture methods.

Scope For Osseointegration: Concept of osseointegration can be used in prosthetic rehabilitation of missing teeth or Complete edentulous maxilla and mandible rehabilitation. Single tooth replacement, Partial dental floss replacement, removable prosthesis, fixed prosthesis; anchorage for the maxillofacial prosthesis such as auricular Prosthesis, ocular prosthesis, nasal prosthesis; for rehabilitation of congenital and developmental defects like cleft palate, ectodermal dysplasia; complex maxillofacial defect rehabilitation; distraction osteogenesis; orthodontic anchorage.

Conclusion: From a periodontologist's point of view, the osseointegration method offers new perspectives in the rehabilitation of partial and total edentulism in cooperation with the prosthodontist or general practitioner. In both situations, the masticatory function can be well restored under secure and predictable conditions. Ongoing research will allow discrimination between those systems that really osseointegrate predictably and those that do this irregularly.

Long term maintenance of dental implants is gaining importance as the main factor affecting the long term prognosis of dental implants. Patients should be well instructed in maintaining oral hygiene around the dental implants. A lot of implant cleansing aids are more widely available in line with the growing demand of dental implants. The presence of attached gingiva is being recognised as important for the maintenance of good oral hygiene in reducing the incidence of periodontal disease around the implants (peri-implantitis). The patients are better informed in committing to regular oral hygiene visits every 6 months and annual check-up with either the surgeons or the prosthodontists.

References:

1. Albrektsson T. Osseointegration : Current state of the art. *Dental Clinics of North America* 1989; 33: 537-555
2. Ritman EL, Bolander ME, Fitzpatrick LA, Turner RT. Micro-CT imaging of structure-to-function relationship of bone microstructure and associated vascular involvement. *Technol Health Care*. 1998;6(5–6):403–412.
3. Sela J, Gross UM, Kohavi D, et al. Primary mineralization at the surfaces of implants. *Crit Rev Oral Biol Med*. 2000;11(4):423–436.
4. Behari J. Elements of bone biophysics. In: Behari J. *Biophysical Bone Behaviour: Principles and Applications*. Chichester: John Wiley & Sons, Ltd; 2009:1–52.
5. Ross FP, Christiano AM. Nothing but skin and bone.*J Clin Invest*. 2006;116(5):1140–1149.
6. Wolff J. *Das Gesetz der Transformation der Knochen*, *Hirschwald*[*The Law of Bone Remodeling*]. Berlin: Springer-Verlag; 1892. German.
7. Skedros JG, Baucom SL. Mathematical analysis of trabecular 'trajectories' in apparent trajectorial structures: the unfortunate historical emphasis on the human proximal femur. *J Theor Biol*. 2007;244(1): 15–45.
8. Carl E. Misch*Contemporary Implant Dentistry*.3rd ed. Missouri: Mosby; 2008.
9. Eriksson AR, Albrektsson T. Temperature threshold levels for heat-induced bone tissue injury: a vital-microscopic study in the rabbit. *J Prosthet Dent*. 1983;50(1):101–107.
10. Rafel SS. Temperature changes during high-speed drilling on bone. *J Oral SurgAnesthHosp Dent Serv*. 1962;20:475–477.
11. Ling RS.Observations on the fixation of implants to the bony skeleton.*ClinOrthopRelat Res*. 1986;(210):80–96.
12. Abrahamsson I, Linder E, Lang NP. Implant stability in relation to osseointegration: an experimental study in the Labrador dog. *Clin Oral Implants Res*. 2009;20(3):313–318.
13. Rae T. The toxicity of metals used in orthopaedic prostheses. An experimental study using cultured human synovial fibroblasts.*J Bone Joint Surg Br*. 1981;63-B(3):435–440.
14. Albrektsson T, Brånemark PI, Hansson HA, Lindström J. Osseointegrated titanium implants.Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man.*ActaOrthop Scand*. 1981;52(2):155–170.
15. Rae T. Comparative laboratory studies on the production of soluble and particulate metal by total joint prostheses. *Arch Orthop Trauma Surg*. 1979;95(1–2):71–79.
16. AginsHJ, Alcock NW, Bansal M, et al. Metallic wear in failed titanium-alloy total hip replacements. A histological and quantitative analysis. *J Bone Joint Surg Am*. 1988;70(3):347–356.
17. Tummler HP, Thull R, Schaldach M.The mechanism of repassivation and the concentration of corrosion products shown on TIALV. Proceedings of the World Congress on Medical Physics and Biomedical Engineering, 13th International Conference on Medical and Biological Engineering, and 6th International Conference on Medical Physics; September 5–11, 1982; Hamburg, Germany.
18. Aaron RK, Herr HM, CiomborDM, et al. Horizons in prosthesis development for the restoration of limb function. *J Am AcadOrthop Surg*. 2006;14(10 Spec No):S198–S204.

19. Kieswetter K, Schwartz Z, Dean DD, Boyan BD. The role of implant surface characteristics in the healing of bone.*Crit Rev Oral Biol Med*. 1996;7(4):329–345.
20. Meyer AE, Baier RE, Natiella JR, Meenaghan MA. Investigation of tissue/implant interactions during the first two hours of implantation.*J Oral Implantol*. 1988;14(3):363–379.
21. Balshe AA, Assad DA, Eckert SE, Koka S, Weaver AL. A retrospective study of the survival of smooth- and rough-surface dental implants.*Int J Oral Maxillofac Implants*. 2009;24(6):1113–1118.
22. Pak HS, Yeo IS, Yang JH. A histomorphometric study of dental implants with different surface characteristics.*J AdvProsthodont*. 2010;2(4): 142–147.
23. Boyan BD, Lohmann CH, Dean DD, Sylvia VL, Cochran DL, Schwartz Z. Mechanisms involved in osteoblast response to implant surface morphology. *Annu Rev Mater Res*. 2001;31:357–371.
24. Meyer U, Joos U, Mythili J, et al. Ultrastructural characterization of the implant/bone interface of immediately loaded dental implants. *Biomaterials*. 2004;25(10):1959–1967.
25. Bloebaum RD, BachusKN, Rubman MH, Dorr LD. Postmortem comparative analysis of titanium and hydroxyapatite porous-coated femoral implants retrieved from the same patient. A case study.*J Arthroplasty*. 1993;8(2):203–211.
26. Hofmann AA, BachusKN, Bloebaum RD. Comparative study of human cancellous bone remodeling to titanium and hydroxyapatite-coated implants.*J Arthroplasty*. 1993;8(2):157–166.
27. Bloebaum RD, Mihalopoulus NL, Jensen JW, Dorr LD. Postmortem analysis of bone growth into porous-coated acetabular components.*J Bone Joint Surg Am*. 1997;79(7):1013–1022.
28. Albrektsson, T. A multicenter report on osseointegrated oral implants.*Journal of Prosthetic Dentistry 1988; 60: 75–84.*
29. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg 1981; 10:387–416.*
30. Esposito M, Thomsen P, Ericson LE, Lekholm U, 1999. Histopathologic observations on early oral implant failures. International Journal of Oral and Maxillofacial Implants, 14:798-810.
31. Ekfeldt A, Christiansson U, Eriksson T, Lindén U, Lundqvist S, Rundcrantz T, Johansson LA, Nilner K, Billström C, 2001. A retrospective analysis of factors associated with multiple implant failures in maxillae. Clinical Oral Implants Research, 12:462-7.
32. Op Heij DG, Opdebeeck H, van Steenberghe D, Quirynen M, 2003. Age as compromising factor for implant insertion. Periodontology 2000, 33:172-84.
33. Fiorellini JP, Chen PK, Nevins M, Nevins ML, 2000. A retrospective study of dental implants in diabetic patients. International Journal of Periodontics and Restorative Dentistry, 20:366-73.
34. Lambert PM, Morris HF, Ochi S, 2000. The influence of smoking on 3-year clinical success of osseointegrated dental implants. Annals of Periodontology, 5:79-89.
35. Jaffin RA, Berman CL, 1991. The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis. Journal of Periodontology, 62:2-4.
36. Roberts WE, Simmons KE, Garetto LP, DeCastro RA, 1992. Bone physiology and metabolism in dental implantology: risk factors for osteoporosis and other metabolic diseases. Implant Dentistry, 1:11-21.
37. Monsees TK, Barth K, Tippelt S, et al. Surface patterning on adhesion, differentiation, and orientation of osteoblast-like cells. Cell Tiss Org 2005;180:81–95.
38. Gupta, A.; Dhanraj, M. &Sivagami, G. Status of surface treatment in endosseous implant: a literary overview. Indianjournal of dental research 2010;21:433-438.
39. Gotfredsen K, Karlsson U.A prospective 5-year study of fixed partial prostheses supported by implants with machined and TiO2-blasted surface. J Prosthodont 2001;10:2-7.
40. Cochran DL, Nummikoski PV, et al. Evaluation of an endosseous titanium implant with sandblasted and acidetched surface in the canine mandible: Radiographic results. Clin Oral Implants Res 1996;7:240-52.
41. Misch Contemporary Implant Dentistry. 3rd ed Mosby .2008. p 614.
42. McCafferty MM, Burke GA, Meenan BJ. Mesenchymal stem cell response to conformal sputter deposited calcium phosphate thin films

on nanostructured titanium surfaces. J Biomed Mater Res A 2013 Nov 1. doi: 10.1002/jbm.a.35018. [Epub ahead of print]

43. CaousJS, Lövenklev M, Fäldt J, Langton M. Adhesion of Streptococcus mitis and Actinomycesoris in co-culture tomachined and anodized titanium surfaces as affected by atmosphere and pH. BMC Oral Health 2013 Jan 8;13:4. doi: 1186/1472-6831-13-4.
44. Herr Y, Woo J, Kwon Y, Park J, Heo S & Chung J. Implant Surface Conditioning with Tetracycline-HCl: A SEM Study. Key Engineering Materials 2008;361:849-852.
45. Vincenzini P, editor: Ceramics in surgery, Amsterdam, 1983, Elsevier.
46. Kou W, Akasaka T, Watari F, Sjögren G. An in vitro evaluation of the biological effects of carbon nanotubecoateddental zirconia. ISRN Dent 2013 August 20;2013:296727. doi: 10.1155/2013/296727.

Conflict of interest: None
Funding: None
Cite this Article as: Dharmapalan J, Nasiha D, Karanjkar A, Bommineni P, Roy P. Osseointegration For Dental Implants- An Overview.Natl J Integr Res Med 2015; 6(3): 105-112