Review of literature

History of dental implant

The Maya civilization has been shown to have used the earliest known examples of endosseous implants (implants embedded into bone), dating back over 1,350 years before Per-Ingvar Brånemark started working with titanium While excavating Maya burial sites in Honduras in 1931, archaeologists found a fragment of mandible of Maya origin, dating from about 600 AD. This mandible, which is considered to be that of a woman in her twenties, had three tooth-shaped pieces of shell placed into the sockets of three missing lower incisor teeth. For forty years the archaeological world considered that these shells were placed after death in a manner also observed by the ancient Egyptians. However, in 1970 a Brazilian dental academic, Professor Amadeo Bobbio studied the mandibular specimen and took a series of radiographs. He noted compact bone formation around two of the implants which led him to conclude that the implants were placed during life.

In the 1950s research was being conducted at Cambridge University in England to study blood flow in vivo. These workers devised a method of constructing a chamber of titanium which was then embedded into the soft tissue of the ears of rabbits. In 1952 the Swedish orthopaedic surgeon, P I Brånemark, was interested in studying bone healing and regeneration, and adopted the Cambridge designed 'rabbit ear chamber' for use in the rabbit femur. Following several months of study he attempted to retrieve these expensive chambers from the rabbits and found that he was unable to remove them. Per Brånemark observed that bone had grown into such close proximity with the titanium that it effectively adhered to the metal. Brånemark carried out many further

studies into this phenomenon, using bothanimal and human subjects, which all confirmed this unique property of titanium.

Dr. Leonard Linkow placed his first dental implant in 1952, four months after he graduated from dental school. By 1992, Dr. Linkow had placed over 19,000 dental implants and stopped counting. He retired from private practice in 2002 leaving a body of work that included 12 books and 36 patents. Many implant dentists refer to Dr. Linkow as the father of modern implant dentistry9.[7]

Meanwhile an Italian medical doctor called Stefano Melchiade Tramonte, understood that titanium could be used for dental restorations and after designing a titanium screw to support his own dental prosthesis, started to use it on many patients in his clinic in 1959. The good results of his clinical studies on humans were published in 1966.[8]

Although Brånemark had originally considered that the first work should centre on knee and hip surgery, he finally decided that the mouth was more accessible for continued clinical observations and the high rate of edentulism in the general population offered more subjects for widespread study. He termed the clinically observed adherence of bone with titanium as 'osseointegration'. In 1965 Brånemark, who was by then the Professor of Anatomy at Gothenburg University in Sweden, placed his first titanium dental implant into a human volunteer. Contemporaneous independent research in the United States by Stevens and Alexander led to a 1969 US patent filing for titanium dental implants.[9]

Over the next fourteen years Brånemark published many studies on the use of titanium in dental implantology until in 1978 he entered into a commercial partnership with the Swedish defense company, Bofors AB

for the development and marketing of his dental implants. With Bofors (later to become Nobel Industries) as the parent company, Nobelpharma AB (later to be renamed NobelBiocare) was founded in 1981 to focus on dental implantology. To the present day over 7 million Brånemark System implants have now been placed and hundreds of other companies produce dental implants. The majority of dental implants currently available are shaped like small screws, with either tapered or parallel sides. They can be placed at the same time as a tooth is removed by engaging with the bone of the socket wall and sometimes also with the bone beyond the tip of the socket. Current evidence suggests that implants placed straight into an extraction socket have comparable success rates to those placed into healed bone.[10]

The success rate and radiographic results of immediate restorations of dental implants placed in fresh extraction sockets (the temporary crowns placed at the same time) have been shown to be comparable to those obtained with delayed loading (the crowns placed weeks or months later) in careful Some current research in dental implantology is focusing on the implants. Zirconia is the dioxide of zirconium, a metal close to titanium in the periodic table and with similar biocompatibility properties.[11]

Types and composition of Implants:

There are three types of implants, and they can be describe according to their shape and how they are attached to the jaw. In the last few years, oral implantology has been gaining attention in modern dentistry .it has become an established and proven treatment modality for replacement of missing dentition , with predictable aesthetic and functional outcomes and high degree of patients' satisfaction[12].

Babbush 3 classified dental implants according to the implantation method into ; endosteal implants, subperiosteal implants, mandibular staple bone plates and mucosal inserts.

An endosteal implant is a prosthetic device of an alloplastic material placed into the alveolar and/or basal bone of the mandible or maxilla .they are the most commonly used implants and represent an excellent relatively simple option to rehabilitate edentulous patients .there are two forms of endosteal implants ;root form implants and plate form implants[14]

Root form implants are implants designed to use vertical column of bone similar to the natural tooth root .they are two basic designs: cylindric or press-fit type and screw or thread type .these implants are presented in different forms ; tapered, stepped, perforated, solid,hollow or vented [15].

Plate form implants are flat shaped implants. this design is commercially known as blade-vent implant ablade-vent implants consists of 3 parts: head , neck and body. plate form implants have a larger surface area ,leading to the spread of masticatory forces over this larger surface area.the primary drawbacks to blade implants remain that it is difficult toprepare a precision slot for blade placement and that a large circumferential area of the jaw may be affected when blades fail.[16]

Subperiosteal implants(SPI) are implants originally casted from Cobalt0Chromium-Molybdenum alloy (Vitalium) and inserted on around the bone surface , rather than in it , under the periosteum. these implants have four to six parallel posts to which the prosthetic superstructure is attached,for the treatment of patients with atrophied alveolar ridges[17]

The first subperiosteal implant was designed and placed in 1940's by gustav dahl in Sweden.the technique was brought to the united states by Goldberg and gershkoff in 1949, which popularized it through the world.[18]

Currently, through advanced computer and radiographic technology, CT generated CAD-CAM anatomically accurate model of the alveolar ridge could be obtained, thus eliminating the need for direct bone impression through surgical interference [19].

Casting subperiosteal implants from titanium is possible and coating subperiosteal implants with hydroxyapatite (HA) is also possible. This improves the implant surface biocompatibility and implant long-term success.[20]

The development of mandibular staple bone plate began in 1960's.it is a trans-osteal implant that is inserted in the anterior moderately resorbed mandible through an extra-oral incision,with several retentive and trans-mucosal pins that anchor the lower denture, with high degree of patient satisfaction.A variation of the staple implant is the smooth staple implant(SSI) that is characterized by interally threaded smooth trans-mucosal pins for an improved stability and retention of the lower prosthesis21.

Meijer et al in their long-term retrospective study of patients treated with the staple implant concluded that the staple implant represent a good modality to stabilize the lower denture. Although mandibular staple implants are not commonly used, because of the complex nature of the surgical approach , still it is a good option to restore very atrophic mandible without the necessity to harvest a bone graft [22,23].

The mucosal insert was developed by dahl and has been used for several years world wide. in fact, mucosal inserts are not true implants. Mucosal inserts are constructed by inserting a small button-like retention element under mucosa for increasing the retention of any well-made denture [24].

Generally mucosal insert is made of titanium, stainless steel or aluminium oxide and consists of three parts; head which is the part of the mucosal insert that is inserted in the sub-mucosa, base which is the part of the mucosal insert that is attached to the prosthesis and neck which is the narrow connection between head and base [25].

Material of dental implants:

By the end of the 19th century, the groundwork was laid for the advances that were to follow in the field of dental implantology. Sterility of instruments and antiseptic/aseptic principles of wound management already had been developed for general and orthopedic surgery. X-rays were discovered in the winter of 1895 in Germany, and their application through radiography quickly followed in the fields of medicine and dentistry in the early months of 1896. The introduction of local anesthesia in 1885, by William Halstead , provided dentists with the opportunity to experiment with. It remained for Greenfield to realize the shortcomings of using natural teeth (slow to rapid root resorption) and to embark on clinical research using a metal substitute. It was his hope that because these metal root substitutes would not resorbed, they would provide a long-lasting artificial platform, anchored in healthy bone, upon which to build dental crowns and bridges.[26]

It was the chance observation of an orthopedic operation, in which silver wire suture was used, that prompted Greenfield to consider the use

of metal in the placement of endosseous dental implants. He envisioned that the metal would be well tolerated by the bone and gingival tissues of the partially edentulous jaws of his patients. The surgical use of silver wire was already well known in the treatment of gynecological problems. Pioneering work by Marion Sims in America and Montague Gosset in England proved that this metal suture was well tolerated by the soft tissues in the successful closure of vesicovaginal fistulas.[27]

Also, in1875, Hugh Owens Thomas of Liverpool, England, described the successful use of silver wire to stabilize the reduced fragments of a fractured mandible.[28]

In 1924, Arthur A. Zierold, a surgeon from the University of Minnesota, undertook a research project using dogs, where he compared the tissue reaction to aseptic surgical implantation of several different metals. Zierold implanted the following metals into different skeletal regions: gold, silver, aluminum, zinc, lead, copper, nickel, high carbon steel, stellite, magnesium, iron, and copper aluminum alloy. After a 2- to 6-week healing period, the dogs were sacrificed and histologic specimens obtained. This was one of the first studies that used histologic techniques to help confirm clinical impressions of biocompatibilty. Though Zierold did not find fusion of bone tissue to any of the metal implant surfaces it was apparent that different metals exhibited different types and degrees of tissue reactions.[29]

San Antonio, Texas, surgeons Venable and Stuck published a series of articles from 1936-1938 in which they researched corrosion as the main cause for the lack of biocompatibility. The metal that was found to exhibit the least degree of corrosion was vitallium, a mixture of cobalt, chromium, and molybdenum. They stated: “We feel that the criterion in

the matter of osteosynthesis with metals is that the metal must be electrically neutral or entirely passive in the presence of body fluids and significantly rigid and strong to do its part mechanically [30,31].

In1951, Gottlieb S. Leventhal of Philadelphia, strongly endorsed titanium as an ideal metal for use in fixation of bone fractures. He suggested this metal because of its superior characteristics with regard to its tensile and yield strength, weight, resistance to corrosion, ability to be welded and forged, and because it could be machined like stainless steel. Leventhal described what years later Brånemark called "osseointegration" when he placed titanium screws in rat femurs. Leventhal stated: "At the end of 6 weeks, the screws were slightly tighter than when originally put in; at twelve weeks, the screws were more difficult to remove; and at the end of 16 weeks, the screws were so tight that in one specime . The femur was fractured when an attempt was made to remove the screw. Microscopic examinations of the bone structure revealed no reaction to the implants. The trabeculation appeared to be perfectly normal."[32]

Implant materials or bio-materials are non-viable materials used in a medical device intended with biological systems [67].There are several materials for fabricating dental implants. Spiekermann68 classified these bio-materials into metals, ceramics and compounds.

Metals:

Most endosteal implants are made of Titaniumand its alloys. Titanium is a biocompatible materials and well tolerated by host tissues. It has no harmful effects on local tissues and has no harmful effects in distant body organs and functions. Titanium can be alloyed with various elements primarily to improve its mechanical properties [33,34,35].

The use of dental implants in the treatment of complete and partial edentulism has become an integral treatment modality in restorative dentistry [36].

Dental implants first appeared as early as 1930 but their clinical use is widespread since about 20 years. Different materials are being used for dental implants. The metallic biomaterials follow the general patterns for metal degradation in environmental situations. Metals undergo chemical reactions with non-metallic elements in the environment to produce chemical compounds. Commonly these products are called as corrosion products. One of the primary requisites of any metal or alloy to be used within the human body is to be bio compatible and hence it should not form or help in forming any such products which may deteriorate the metal itself and be harmful.

The oral cavity is subjected to wide changes in pH and fluctuation in temperature. The disintegration of metal may occur through the action of moisture, atmosphere ,acid or alkaline solution & certain chemicals Further it has been reported that water, oxygen, chlorides, sulphur corrode various metals present in dental alloys.

Titanium has long been successfully used as an implant materialTitanium is widely used in odontology because of its excellent characteristics such as chemical inertia, mechanical resistance, low density, absence of toxicity, resistance to corrosion and biocompatibility[37,38].

Biocompatibility has been defined as the state of mutual coexistence between the biomaterials and the physiological environment such that neither has an undesirable effect on the other.[39] It is the ability of a material to perform with an appropriate host response in a specific

application.40This means that the tissues of the patient that comes into contact with the materials does not suffer from any toxic, irritating, inflammatory, allergic, mutagenic or carcinogenic action [41,42]

For dental implant, biocompatibility depends on both mechanical and corrosion/degradation properties of the material. Corrosion, the gradual degradation of materials by electrochemical attack is a concern particularly when a metallic implant is placed in the hostile electrolytic environment provided by the human body.[43]

Titanium is reactive metal;in air,water or any electrolyte, an oxide layer is spontaneously formed on the surface of the metal.The titanium ions surface oxide layer (Tio2) is very adherent layer that covers the metal and prevent a direct contact between the potentially harmful metallic ions and the tissues [44] .

Titanium has good mechanical properties such as tensile strength, toughness and malleability .It is stronger than cortical bone and dentine with an excellent corrosion resistance [45,46].Titanium alloy (Ti-6AL-4v) is composed of titanium alloyed with 6% aluminium and 4%vanadium. Aluminium increases strength of the alloy while Vanadium serves as aluminium scavenger,presumabiy preventing corrosion [47].

Ceramics

Awide variety of ceramic materials are frequently used in dentistry. The application ranges from veneering material for metal substructures، through all-ceramic posts andcores towards frameworks for crowns and bridgework.

Ceramics are inorganic non-metallic materials produced by compacting powder at very high temperatures. Bio-ceramic used for

medical applications, mainly in orthopaedic and oral maxillofacial surgeries . Bio-ceramic include Bio-active glasses (BAGs), aluminium oxide (Alumina Al2O3), Zirconium dioxide (Zirconia, ZrO2) and calcium phosphate [48].

Bioactive glasses (BAGs) such as Bioglass45S5 is abio-active silica gel of 45% silicon dioxide (SiO2), 24% calciumoxide(CaO), 24.5% sodium oxide (Na2O) and 6.0% phosphate pentoxide (P2O2) by weight98 . Bioactive glasses are used as an augmentation material for repairing bony defects in low- load bearing areas [49,50]. They speed up the fixation of the implant by promoting bone ingrowth and allowing faster mechanical interlocking of the dental implant in the host bone [51] .

Aluminium oxide (Al2O3) is a hard , but brittle, implant material with an excellent biocompatibility52. Because its colour is similar to that of natural teeth and du to light tansmission properties , the grayish gingival discolcoration sometimes observed with metal abutments is avoided [81].

Zirconium dioxide (Zirconium, ZrO2) is abiomaterial that has high mechanical strength and fracture toughnees. The use of Zirconia ceramics as biomaterials commenced about twenty years ago. [53]

Calcium phosphate ceramics still remain the most biocompatible implant material known and possess the added feature of becoming strongly bonded to living bone through natural bonding mechanisms .

They have relatively high chemical reactivity and weak mechanical profile [54].

Polymers

A vaiety of polymers, polyurethane, polyamide fibers polymethylmethacrylate resin have been used as implant materials [55].

It was hoped that their flexibility would mimic the micromovements of the periodontal ligament and possibly allow connection of the natural teeth. However their inferior mechanical properties and poor biological response have limited their use. [56]

Implant form:

As the 20th century started, dentists continued to search for materials and designs that would survive for more than a brief period after implantation. The first major breakthrough came in 1941 when a Swedish doctor, named Gustav Dahl, placed a metal structure below the periosteum; vertical extensions protruded through the gingival [57] .

This breakthrough led to the development of the technique for placing subperiosteal implants in the United States by two dentists, Aaron Gershkoff and Norman Goldberg, from Providence, subperiosteal implants consist of a metal framework that attaches on top of the jaw bone but underneath the gum tissue.

Another breakthrough came with the work of Leonard I. Linkow of New York, who in 1964 introduced a blade implant that eventually became the most widely used implant design in the 1970s. The name of the implant derived from their blade-like portion which is the part that gets embedded into the bone . Blade implants are not used frequently in present time due to their weak tolerance to stress and strain. However, they do find an application in areas where the residual bone ridge of the jaw is too thin to place root form implants58.

Biomechanical Design of Dental Implants:

It is quintessential to understand the fundamentals and the components of the implant before introducing any new design, modifications, to the clinically proven Branemark dental implant (95% success for implants in the mandible and 85~90% for the maxilla after 5 years) [59,60].

Implant diameter is the dimension measured from the peak of the widest thread to the same point on the opposite side of the implant. It is considered to be more important than the implant length in the distribution of loads to the surrounding bone. At least 3.25 mm in diameter is required to ensure adequate implant strength and most implants are approximately 4 mm in diameter. From a biomechanical standpoint, the use of wider implants allows an engagement of a maximal amount of bone, and a theoretically improved distribution of stress in the surrounding bone [61,62].

It has been confirmed that more bone contact area provides increased initial stability and resistance to stresse .The increase in diameter will result in a higher percentage of bone contact by increasing the surface area of the implant. Previous research, done by Misch CE et al, shows that increasing the diameter in a 3 mm implant by 1 mm increases the surface area by 35% over the same length in overall surface. [63,64].

Another research, done by Mahon JM et al, shows that increasing the diameter of an implant results in a decrease in the abutment strain for a given load. This means that an implant can obtain improved implant strength and resistance to fracture by appropriately increasing the diameter of implants. [65]

Implant length is the dimension from the platform to the apex of implant. Most common lengths are between 8 and 13mm which correspond quite closely to normal root length. It has been an axiom in the implant dentistry that longer implants guarantee better success rates even though there is no proven linear relationship between implant length and success rate of the implant. [61]

The use of short implants has not been recommended because it is believed that occlusal forces must be dissipated over a large implant surface area to prevent excessive stresses at the interface. Over the years The relationship between initial mobility and implant length has not been established. Several mechanical analyses have supported the view that increasing the implant length may only increase success rate to a certain extent. [66]

There are basically four types of prosthetic attachment: the external hex, internal hex, internal taper (morse taper), and spline. An ideal prosthetic attachment is one that will allow complete security in the union and the ability to replace components in exactly the same orientation at any time. It should also allow for a variety of prosthetic components and have a means of providing for alignment correction in cases of mal placement.[67]

Surface roughness

Response of the tissues to the implant is largely controlled by the nature and texture of the surface of the implant. Compared to smooth surfaces, textured implants surfaces exhibit more surface area for integrating with bone via osseointegration process. Textured surface also allows ingrowth of the tissues. [68,69]

The role of surface topography has been the interesting area of investigation in implant dentistry for several years. Several types of implant surface textures are currently available for clinical use. Some of these have the ability to enhance and direct the growth of bone and achieve osseointegration when implanted in osseous sites. [70]

Endosseous dental implants are available commercially with many different surface configurations. Most implant systems of this category are based on the fact that bone tissue can adapt to surface irregularities in the 1 – 100 micron range, and that altering the surface topography of an implant can greatly improve its stability. [69]

Surface topography of an implant can be designed by making porous and/or by coating the implant surface with other suitable materials to increase bone-implant contact since the anatomic surface of bone cannot be controlled. [71]

A number of surface treatments are available to create controlled roughness on the surface of the implants. Roughness can be produced on the implant surfaces through the addition or subtraction procedures. A plasma arc is a kind of addition process, which involves the deposition of bioactive hydroxyapatite material on the surface of the implants .

These treatments may also be classified into mechanical, chemical, electrochemical, electropolishing, vacuum, thermal and laser methods. [72]

In addition to creating surface topography on the implant, some of these methods also produce sterile surfaces on the implant surfaces. [73]

Implant surface coating:

One approach to achieve faster loading by enhancing tissue responses at dental implant interfaces has been the introduction of ceramic- like calcium-phosphate (CP) containing materials as implant devices. One of the most important uses of CP materials has been the coating on metallic substrates; the most commonly used CP material type to coat metallic substrates is Hydroxyapatite (HA). HA is biocompatible and bioactive in the body. HA also displays an osteoconductivity; a property that encourages bone being formed to lie closely, or adhere, to a material's surface. This is especially useful for an implant where fast healing is required [74.75].

Favorable clinical results were reported for HA coated implants. They have a higher integration rate, promote faster bone attachment, and achieve direct bone bonding with higher interfacial attachment strength to bone when compared to uncoated metallic implants [76].

HA dental implants are regarded as the benchmark of the dental implant surface treatment. However, HA coated dental implants have also been associated with clinical problems as well. One of the major concerns with plasma-sprayed coatings is the possible delamination of the coating from the surface of the titanium implant and the failure at the implant-coating interface despite the fact that the coating is well-attached to the bone tissue. The different layers of HA coating have been often reported to cause delamination and particle release under fatigue stress resulting in clinical failure of implants. [77,78]

Coating delamination has been reported in dental situations where the efficacy of plasma spraying is not optimal due to the size of the dental implants . Loosening of the coating has also been reported, especially

when the implants have been inserted into dense bone [79,80]. For all of the above reasons, the clinical use of plasma-sprayed HA coated dental implants is limited.

Magnesium is a biocompatible lightweight metal. Magnesium has a very unique characteristic of dissolving readily in an aqueous solution that contains chloride ions .It has been reported that magnesium forms a soluble and non-toxic oxide in body fluids that is harmlessly excreted with the urine .Due to this unique characteristic, in the recent years, there has been significant increase in the research on magnesium and magnesium-based alloys into a development of new biodegradable orthopedic material. [81,82,83]

However, the fast corrosion of pure magnesium in the physiologic environment with pH level (7.4-7.6) and high chloride concentration prevents the orthopedic use of an implant made of pure magnesium alone.[84]

Mechanical treatments:

Mechanical methods involve treatment, shaping or removal of the material surface by means of physical forces. Mechanical treatments involve either removal of surface material by cutting or abrasive action, or the surface of the implant is deformed (and/or partially removed) by particle blasting. Grinding and mechanical polishing are identical methods in that they remove some of the surface material by using a hard abrasive [80.85,86]

Chemical treatments:

A variey of chemical treatments such as solvent cleaning, wet chemical etching, and passivation treatments have been employed for modifying the implant surfaces. Solvent cleaning is mainly aimed at cleaning the surface of the implant from oils, greases and fatty surface contaminants remaining after manufacturing process by using organic solvents (aliphatic hydrocarbons, alcohols, ketones or chlorinated hydrocarbons), surface active detergents and alkaline cleaning solutions. For affective cleaning the process may be carried out at elevated temperatures with or without the use of ultrasonication.[85]

This process does not have any affect on the surface of the implant. Selection of a solvent is based on the type of material to be cleaned and type of contamination to be removed from the material .

Wet chemical etching dissolves the native surface layer of the implant material including the oxide layer and parts of the underlying metal. Chemical etching is also used to improve the surface roughening as well as for producing an aesthetically favorable surface finish. Because the titanium dioxide on the surface of the implant is a stable one, choice of etchants is limited to few acids and alkalinesolutions. Acid etching or pickling is used for removing oxide layer to obtain clean and uniform surface finish. An aqueous mixture of 10-30 volume % of nitric acid; (69 mass%) and 1-3 volume% of hydrofluoric acid (60 mass%) [2,23,30] is the most commonly used ecthing solution.[85,87,88]

Alkaline etching is a simple technique to modify the titanium surfaces. Treatment of titanium in 4-5 M sodium hydroxide at 600 oC for 24 hours has been shown to pro-duce sodium titanate gel of 1 ìm thick, with an irregular topography with high degree of open porosity.

Composition and structure of this layer can be further modified by proper heat treatment. Alternatively, boiling alkali solution (0.2 M sodium hydroxide, 1400 oC for 5 h)can be used to produce a high density of nanoscale pits on the titanium. When the alkali treatment is preceded by etching in hydrochloric acid/sulfuric acid, porosity of the final surface is found to increase [89]

Passivation treatments are used for obtaining a uniformly oxidized surface to improve corrosion resistance. It is often the last step in the surface preparation of the implants. Immersion of the titanium for a minimum of 30 minutes in 20-40 vol% solution of nitric acid at room temperature is the most commonly employed method. After the passivation, surface of the implant should be neutralized, thoroughly rinsed and dried. Nitric acid passivation has no major influence on the overall surface topography of titanium surfaces. [88]

These treatments do not show any major changes in the overall surface topography, as compared to nitric acid passivation.

Electrochemical treatments:

Electropolishing and anodic oxidation, also known as anodizing, are the most commonly used methods for titanium surface modification. They are based on different chemical reactions occurring at an electrically energized surface (electrode) placed in an electrolyte. The specimen to be treated is made the anode and by controlling the variables such as choice of electrolyte and other processing parameters such as electrode potential, temperature, current etc., to obtain different effects on the sample (anode) surface. [90]

Vacuum treatments:

Vacuum treatment offers superior control on the processing conditions, especially with respect to cleanliness. Glow-discharge treatment, also known as cold plasma treatment, is based on the action of a low-pressure electrical discharge on the surface of the implant. Two different types of plasma treatments are available such as plasma deposition method and plasma surface modification. In plasma deposition, glow discharge is used to deposit the coating material from a separate solid target (sputter deposition) and/or by reactions in the gas phase (reactive sputtering or plasma polymerization). Plasma treatment increases the surface energy of the implant and there by improves the wetting characteristics as compared to conventional implant surfaces cleaned by using solvents or autoclaving. [91,92]

Thermal treatments:

Commercially pure titanium was thermally annealed up to 1000°C to form oxide layer composed of anatase and rutile structures of TiO2 on the surface which is crack-free and uniformly rough. The average roughness of the oxidized surface observed when the titanium is annealed at 600 oC and 650 °C for 48 hours was 0.90 and 1.30 ìm, respectively where as the average roughness of untreated sample was 0.08 ìm. Thermal treatment at 600 o C and 650 °C for 48 hours is considered appropriate for implanted mater.[93]

Laser treatments:

Implant surface roughening using the previously discussed methods would cause surface contamination. Laser techniques have recently been developed as an alternative to these techniques. Laser enables implant surface treatment without direct contact and provides better control

surface roughness of implants. Laser treatments are clean and easy method to perform. The average surface roughness of the laser treated acid-etched implantwas 2.28 ìm. Clinical studies have indicated more bone formation around the laser treated implants. [94,95,96]

Implant surface treatment results in a higher percentage of bone to implant contact (BIC),which allows earlier functional loading in healthy patients with good bone quality and quantity with high success rate. [93,94]

Implantation Methods:

Transfixation , submucosal , subperiosteal and endosteal implants are implantation methods available in dental implant surgery [(8,11).]The major differences amond the methods are dependent on their morphology and method of osseous incorporation ([11]). The transfixation implant system is the most traditional method used since 1943 and it has been improved by clinicians through years later .the concept of the system is by the use of metal or ceramic pin inserted down the root of a tooth and into surrounding bone [(8)]

The submucosal method on the other hand involves the retention of elements under the mucosa membrane however it is no longer used due to high bone loss in the posterior maxilla. the subperiosteal implants introduced by Muller (1937) and Dahl (1943).they are not anchored inside the bone as endosseous devices but are shaped to ride on the rest bony ridge and are connected to bone by fibrous tissue . As implant material vitallium, aluminiumoxide, carbons have been used . Many of these implants should have to be removed because of inflammation, swelling and bone resorption [100]

Endosteal Implants are the only ones that have great acceptance. They are surgically placed into the implant bed. A standardized range of

drills is used for preparing the implant bed for various types . the endosteal implants are stabilized in bone via a solid bond ,termed osseointegration or ankylotic anchorage. The endosteal implants should meet some specific conditions to achieve long –term success:

Function: An endosteal implant should replace the missing function of teeth.

Iongevity: An implant should preserve itself and surrounding tissues.

Biocompatibility: The interaction between the implant and vital tissues should be so minimal that the surrounding bone , epithelium , sub-epithelium and the associated vascular and never supply should not be damaged.101

BONE GRAFTS AND BONE SUBSTITUTES

In daily clinical practise we frequently encounter situations in which the bone volume is insufficient for an ideal dental implant placement. Bone regeneration can provide the structural support necessary in these cases. Procedures such as sinus lifting and alveolar ridge augmentation have reached high levels of predictability and already are of major importance in implant practise. Interest for bone substitutes for alveolar ridge augmentation or preservation appears in the early 1980. alongside the development of endoosseous dental implants. Although first studies regarding bone substitutes dates from 1920 by Albee (Albee, 1920), until 1980´s there are very few studies in reference this issue. From 1980´s until nowadays an exponential number of studies about bone substitutes have been made.

The reason for this increasing interest in bone substitutes stems from the fact that about 10-20% of the patients that need treatments with dental

implants, require bone regeneration procedures before implant placement. Moreover, more than 60% of the population in industrialized countries need dental prosthetic replacements (Peterson, 2006), ideally with implants. This is the reason why the market of dental implants is experiencing an increase of approximately 15% every year.

The term .“bone graft.” was defined by Muschler (Bauer, 2000) as: .“any implanted material that alone or in combination with other materials promotes a bone healing response by providing osteogenic, osteoinductive or osteoconductive properties.”. An osteogenic material can be defined as one that has inherent capacity to form bone, which implies to contain provides biologic signals capable to induce local cells to enter a pathway of differentiation leading to mature osteoblasts.

An osteoconductive biomaterial provides a three-dimensional interconnected scaffold where local bone tissue may regenerate new living bone. However, osteoconductive biomaterials are unable to form bone or to induce its formation.

Another property that is interesting to find especially in bone substitutes is biodegradability. This is defined as the capacity of degradation of a particle by two mechanisms principally; through a passive chemical degradation or dissolution, and through active cellular activity mediated by osteoclast and/or macrophages.

Moreover, the biological properties of bone substitute biomaterials are also influenced by their porosity, surface geometry and surface chemistry. The events leading to bone healing and regeneration are influenced by all the variables mentioned above. These properties are related to the biomaterial itself, however,host factors such as bone quality, vascularity of the graft bed and tobacco addiction may also

influence the final outcome of a bone regeneration procedure with a bone substitute.

Biomaterials used for bone regeneration in implant dentistry:

Bone grafting is possible because bone tissue, unlike most other tissues, has the ability to regenerate completely if provided the space into which to grow. As native bone grows, it will generally replace the graft material completely, resulting in a fully integrated region of new bone. The biologic mechanisms that provide a rationale for bone grafting are osteoconduction, osteoinduction and osteogenesis [12]

Osteoconduction occurs when the bone graft material serves as a scaffold for new bone growth that is perpetuated by the native bone. Osteoblasts from the margin of the defect that is being grafted utilize the bone graft material as a framework upon which to spread and generate new bone.12 In the very least, a bone graft material should be osteoconductive.

Osteoinduction involves the stimulation of osteoprogenitor cells to differentiate into osteoblasts that then begin new bone formation. The most widely studied type of osteoinductive cell mediators are bone morphogenetic proteins (BMPs).12A bone graft material that is osteoconductive and osteoinduction will not only serve as a scaffold for currently existing osteoblasts but will also trigger the formation of new osteoblasts, theoretically promoting faster integration of the graft.

Osteogenesis occurs when vital osteoblasts originating from the bone graft material contribute to new bone growth along with bone growth generated via the other two mechanisms.[12]

Bone graft materials can be divided in four large groups: Autografts, Allografts, Xenografts and Synthetic biomaterials.

Autograft:

Autologous (or autogenous) bone grafting involves utilizing bone obtained from the same individual receiving the graft. Bone can be harvested from non-essential bones, such as from the iliac crest, or more commonly in oral surgery, from the mandibular symphysis (chin area) or anterior mandibular ramus (the coronoid process); this is particularly true for block grafts, in which a small block of bone is placed whole in the area being grafted. When a block graft will be performed, autogenous bone is the most preferred because there is less risk of the graft rejection because the graft originated from the patient's own body [102]. As indicated in the chart above, such a graft would be osteoinductive and osteogenic, as well as osteoconductive. A negative aspect of autologous grafts is that an additional surgical site is required, in effect adding another potential location for post-operative pain and complications [103]

Autologous bone is typically harvested from intra-oral sources as the chin or extra-oral sources as the iliac crest, the fibula, the ribs, the mandible and even parts of the skull.

All bone requires a blood supply in the transplanted site. Depending on where the transplant site is and the size of the graft, an additional blood supply may be required. For these types of grafts, extraction of the part of the periosteum and accompanying blood vesels along with donor bone is required. This kind of graft is known as a free flap graft.

Allograft:

Allograft bone, like autogenous bone, is derived from humans; the difference is that allograft is harvested from an individual other than the one receiving the graft. Allograft bone in taken from cadavers that have donated their bone so that it can be used for living people who are in need of it; it is typically sourced from a bone bank. There are three types of bone allograft available:[104]

1. Fresh or fresh-frozen bone
2. Freeze-dried bone allograft (FDB)
3. Demineralized freeze-dried bone allograft (DFDBA)

Artificial bone can be created from ceramics such as calcium phosphates (e.g. hydroxyapatite and tricalcium phosphate), Bioglass and calcium sulphate; all of which are biologically active to different degrees depending on solubility in the physiological environment (see: Hench 'Bioceramics: From Concept to Clinic' 1991, Journal of the American Ceramic Society). These materials can be doped with growth factors, ions such as strontium or mixed with bone marrow aspirate to increase biological activity. Some authors believe this method is inferior to autogenous bone grafting [2] however infection and rejection of the graft is much less of a risk, the mechanical properties such as Young's modulus are comparable to bone. The presence of elements such as strontium can result in higher bone mineral density and enhanced osteoblast proliferation in vivo.

Xenografts

Xenografts are derived from other species. They are materials with their organic components totally removed. With their removal, concern about immunological reactions becomes nonexistent. The remaining

inorganic structure provides a natural architectural matrix as well as an excellent source of calcium.

The inorganic material also maintains the physical dimension of the augmentation during the remodeling phases.105,106

Properties of graft granules

A number of studies have demonstrated that osseointegration and osteoconduction processes are influenced by physical and chemical properties of the material, including granule size, granule morphology, crystallinity and porosity, surface roughness, and ratio of calcium to phosphate (Ca:P) in the composition.

Nevertheless, the requirements the best performance for these biomaterials have not been thoroughly addressed.[107]

Misiek et al. compared sharp-edged and rounded Hydroxyapatite (HA) granules and observed that although a mild inflammatoryresponse was seen at the implant sites with both particle shapes, inflammation resolved faster in sites implanted with rounded granules [108]

Yang et al109 stated that the dissolution and crystallinity of HAs were related in a negative manner in vitro. The Ca:P ratio in the composition of HAs seems to directly affect crystallinity.Thus, highly crystalline HA-Ca10 (PO4) 6(OH)2-has a Ca:P molar ratio of 1.67, whereas less crystalline bioceramics, such as tricalcium phosphate and tetracalcium phosphate,are respectively [110]

Takeshita et al.[111] observed that nonporous HA granules grafted into bone defects surrounding titanium implants resulted in fibrous encapsulation during the early healing stages.

Deligianni et al. [112] used a bone marrow cell culture model to demonstrate that cell adhesion, proliferation, and detachment strength increased as the roughness of HA increased.

Oonishi et al,[113] evaluated HA with granules of 1 to 3 lm, 10 lm, and 100 to 300 lm in diameter and noticed that a minimal size of 10 lm was necessary to enable a direct contact between bone and the particles.

Porous hydroxyapatite is quite effective in substituting for and regenerating damaged bones. The porosity coupled with the bioactivity of the material, allow ingrowth and attachment to achieve full integration with living bone. The bone ingrowth and attachment to the body tissue depends on pore geometry [114]

Due to relatively low strength and fracture toughness of hydroxyapatite, zirconium dioxide (Zirconia, Zro2) is one of the most widely used reinforcing agents, because of its super strength and fracture toughness.[115]

Alloplastic grafts are transplants using synthetic biocompatible osteo-conductive materials. They can be classified into ceramic, polymers and composites. Ceramics are most commonly used which may be bio-inert as aluminium oxide and titanium oxide or bioactive as calcium phosphate.[116]

Bioinert ceramic do not have direct bonding with host bone but they are mechanically attached to bone, while bioactive ceramic have the ability to bond with bone. Bioactive ceramics used for bone augmentation includes calcium phosphate such as synthetic hydroxyapatite.[117]

Guided bone regeneration (GBR)

Predictable formation of a direct bone-to implant interface is a treatment goal in implant dentistry. For this purpose, the existence of appropriate bone quality and quantity is necessary and important Loss of alveolar bone may occur prior to tooth extraction because of periodontal disease, periapical pathology, or trauma to teeth and bone. Damage to the bone tissues during tooth extraction procedures may also result in bone loss. Finally, alveolar bone atrophy after tooth extraction is a well-known phenomenon. Sufficient alveolar bone volume and favorable architecture of the alveolar ridge are essential to obtain ideal functional and esthetic prosthetic reconstruction following implant therapy.1

Four methods have been described to increase the rate of bone formation and to augment bone volume: osteoinduction using appropriate growth factors osteoconduction where a grafting material serves as a scaffold for new bone growth, distraction osteogenesis by which a fracture is surgically induced and the two fragments are then slowly pulled apartand finally, guided bone regeneration (GBR) which allows spaces maintained by barrier membranes to be filled with new bone [119,120,121,122]

GBR is based on principles of guided tissue regeneration (GTR).GTR was first developed in the early 1980s by Nyman et al. This concept is based on the principle that specific cells contribute to the formation of specific tissues.[123,124]

Melcher described the concept of selective cell repopulation of defects to enhance healing.124Exclusion of fast-growing epithelium and connective tissue from a periodontal wound for 6 -8 weeks allows the

slower growing tissues including osteoblasts, cementoblasts, and periodontal ligament cells, occupy the space adjacent to the tooth.[123,125]

GBR concept employed the same principles of specific tissue exclusion but was not associated with teeth. Thus the term applied to this technique was guided bone regeneration (GBR). Dahlin and colleagues spearheaded early research on GBR in an attempt to solve the confounding problem of reconstructing large osseous defects in the jaws and for the treatment of the atrophic maxilla or mandible. It is known that to accomplish the repair of a bone defect, the rate of osteogenesis growing in from the surrounding muscle or connective tissue.[122,126,118]

In 1988, Dahlin et al.[122] published the results of animal experimentation on the healing of bone defects. Bilaterally, a through-and through defect was surgically created in the ramus of 30 Sprague-Dawley rats. On one side of the jaw, the defect was covered with a porous polytetrafluoroethylene (PTFE) membrane (Gore-Tex®). The other side served as the control, without a membrane covering.

After 3, 6 and 9 weeks of healing, the specimens were evaluated macroscopically and histologically by light microscope. Statistical analysis of the healed sites demonstrated a highly significant increase in bone regeneration on the membrane side as compared to the control .

Dahlin et al.127 evaluated the principle of GTR to generate bone at the exposed parts of titanium implants. Thirty ‘‘commercially pure’’ 10 mm titanium implants were placed in the tibia of 15 adult rabbits, each with three to four exposed threads per implant. A PTFE membrane was placed over the test fixtures, covering the threads and 5 to 8 mm of the adjacent bone. The muscle and periosteum were replaced, adapted and sutured. The control fixtures were not covered with a membrane. After

healing periods of 6, 9 and 15 weeks, the specimens were removed and evaluated grossly and histologically. The results showed that all exposed threads of the titanium implants were covered with newly formed bone at a uniform thickness, even as early as 6 weeks. New bone formation also was seen in the control areas, although to a much lesser extent than the test areas. It was shown that by placing an inert membrane with an appropriate pore size that hindered the penetration of undesirable cells, a space was created that permitted the entrance of osteogenic and angiogenic cells from the adjacent bone marrow to populate the area and proliferate. It was also recognized that the amount of new bone formation was contingent upon the amount of space created by the membrane.

Schenk et al.[128] histologically demonstrated that bone regeneration in membrane-protected defects healed in a sequence of steps that simulated bone formation of woven bone initially along new blood vasculature at the periphery of the defect. The new vascular supply emanated from surgically created perforations in the cortical bone. The woven bone was subsequently replaced by lamellar bone, which resulted in mature bone anatomy. Ultimately, bone remodeling occurred with the new secondary osteons being formed .

Because the objective of GBR is to regenerate a single tissue namely bone, it is theoretically easier to accomplish it compared to GTR that requires the regeneration of bone, periodontal ligament (PDL) and cementum to form a new periodontal apparatus.[122]

More than two decades have passed from the introduction of GBR into clinical practice. Today, the general understanding of the mechanisms leading to regeneration of desired tissues still agrees with the initially published statements.[123]

Principles of guided bone regeneration :

To achieve better clinical outcomes, the GBR barrier should possess the following properties:[129]

- Cell exclusion: In GBR, the barrier membrane is used to prevent gingival fibroblasts and/or epithelial cells from gaining access to the wound site and forming fibrous connective tissue .
- Tenting: The membrane is carefully fitted and applied in such a manner that a space is created beneath the membrane, completely isolating the defect to be regenerated from the overlying soft tissue. It is important that the membrane be trimmed so that it extends 2 to 3 mm beyond the margins of the defect in all directions. The corners of the membrane should be also rounded to prevent inadverten flap perforation .
- Scaffolding: This tented space initially becomes occupied by a fibrin clot, which serves as a scaffold for the in-growth of progenitor cells. In GBR, the cells will come from adjacent bone or bone marrow
- Stabilization: The membrane must also protect the clot from being disturbed by movement of the overlying flap during healing. It is therefore often, but not always, fixed into position with sutures, mini bone screws, or bone tacks. Sometimes, the edges of the membrane are simply tucked beneath the margins of the flaps at the time of closure, providing stabilization .
- Framework: Where necessary, as in nonspace maintaining defects such as dehiscences or fenestrations, the membrane must be supported to prevent collapse . .

Wang and Boyapati130 proposed the PASS principles for predictable bone regeneration in 2006. To attain horizontal and/or vertical bone augmentation beyond the envelope of skeletal bone, four principles are needed to be met: exclusion of epithelium and connective tissue, space maintenance, stability of the blood clot, and primary wound closure .

Barrier membranes

There are five criteria considered important in the design of barrier membranes used for GTR.131,132 These include biocompatibility, cell occlusiveness, space making, tissue integration and clinical manageability. Various types of materials have been developed, which can be grouped together as either non-resorbable or resorbable membranes .

- **Non-resorbable membranes :**

The first membranes used experimentally by Nyman's group in their initial work were constructed from Millipore® (cellulose acetate) filters. As this technique became more prevalent, the first commercial membrane was produced from Teflon® (e-PTFE). This membrane consisted of 2 parts:

A collar portion, having open pores to allow in-growth of connective tissue and to prevent epithelial migration; and an occlusive portion, preventing the flap tissues from coming into contact with the root surface.This membrane is the gold standard of GTR and GBR treatments.[133]

PTFE is a synthetic fluoropolymer that relies on an extremely strong bond between carbon and fluorine for its nondegradable, biologically

inert properties. There is no known enzyme in the body capable of cleaving carbonfluorine bonds. Added rigidity of the material, PTFE, can be achieved by reinforcement with fluorinated ethylene propylene, resulting in ePTFE.[134]

Study by Buser et al.135 was one of the first to report successful ridge augmentation with GBR in humans using an e-PTFE membrane and tenting pins. The gain in new bone formation ranged from 1.5 to 5.5 mm .

Creation and maintenance of sufficient space underneath the barrier is an important factor for a successful result .

Lundgren et al. compared guided bone regeneration by PTFE membranes with titanium foils. The most regeneration was seen in defects underneath the titanium foils, particularly if they had perforations. The authors suggested the possibility that cells and fluids necessary for nourishment had passed through the perforated foils and aided regeneration.[137]

Since 1995, titanium membranes with microperforations (FRIOS BoneShield, Friatec, Mannheim, Germany) have been used for guided bone regeneration. The membranes are either triangular or oval. The mechanical properties of the membrane prevent collapse of the membrane and provide a constant volume underneath it and areas of microporosity that are small enough to prevent soft tissue penetration through the membrane permit diffusion of interstitial fluid.[138]

High surface roughness of ePTFE membranes facilitates adhesion of bacteria. Thus, primary closure over the membrane needs to be achieved to avoid exposure to the oral environment and resultin bacterial colonization because the resulting inflammation can impair the treatment

outcome. Furthermore, the removal of ePTFE membranes often necessitates a second surgical procedure.139

- Resorbable membranes :

There are two types of biologically resorbable membranes :

1. polyglycoside synthetic copolymers: polylactic acid (Guidor®), polyglactide and polylactide (Resolute), polyglactin 910 (Vicryl ؛(®
2. collagen.[134]

Collagen membranes share in common with all resorbable membranes the fact that they do not require a second surgery for retrieval .

This saves time and cost and is greatly appreciated by patients. Collagen is the principal component of connective tissue and provides structural support for tissues throughout the body.Properties of collagen membranes are mentioned below: Hemostasis: Collagen is hemostatic agent and possesses the ability to stimulate platelet attachment and to enhance fibrin linkage, which may facilitate initial clot formation and clot stabilization, leading to enhanced regeneration.[129]

Chemotaxis: Collagen has been shown to be chemotactic for fibroblasts in vitro. This property could enhance cell migration in vivo.[129]

Ease of manipulation: collagen can be easily manipulated and adapted.[129]

Well tolerated: Collagen has been demonstrated to be a weak immunogen and is therefore, well tolerated by patients. Membranes

made of bovine collagen do not elicit an antibody response when used in GTR.[129]

Bioresorbable: Because collagen is bioresorbable, during enzymatic degradation, it will incorporate with the flap to support new connective tissue attachmentThis may result in augmenting tissue/flap thickness to protect further bone formation. Slow absorption: Membranes must remain in place until cells capable of regeneration are established at the wound site. Collagen membranes cross-linked with formaldehyde have been shown by Blumenthal to last 6 to 8 weeks before being absorbed, whereas noncross linked membranes lose their structural integrity in 7 days.[140,141]

Degradation of resorbable membranes is accomplished by various mechanisms present within the periodontal tissues. The primary structural component of most commerciall yavailable collagen membranes is type I collagen ,which is degraded by endogenous collagenase into carbon dioxide and water. Cross linkage of collagen fibers can affect the rate ofdegradation.142

Osseointegration:

Osseointegration is also defined as : "the formation of a direct interface between an implant and bone, without intervening soft tissue [142] **Osseointegrated implant** is a type of implant defined as "an endosteal implant containing pores into which osteoblasts and supporting connective tissue can migrate".[144] Applied to oral implantology, this refers to bone grown right up to the implant surface without interposed soft tissue layer. No scar tissue, cartilage or ligament fibers are present between the bone and implant surface. The direct contact of bone and

implant surface can be verified microscopically. Osseointegration may also be defined as:

1. Osseous integration, the apparent direct attachment or connection of osseous tissue to an inert alloplastic material without intervening connective tissue.
2. The process and resultant apparent direct connection of the endogenous material surface and the host bone tissues without intervening connective tissue.
3. The interface between alloplastic material and bone.

In 1952, Per-Ingvar Brånemark of Sweden conducted an experiment where he utilized a titanium implant chamber to study blood flow in rabbit bone. At the conclusion of the experiment, when it became time to remove the titanium chambers from the bone, he discovered that the bone had integrated so completely with the implant that the chamber could not be removed. Brånemark called the discovery "osseointegration," and saw the possibilities for human use .In dental medicine the implementation of osseointegration started in the mid-1960s as a result of Brånemark's work.[145,4]

In 1965 Brånemark, who was at the time Professor of Anatomy at the University of Gothenburg, placed dental implants into the first human patient - Gosta Larsson. This patient had a cleft palate defect and required implants to support a palatal obturator. Gosta Larsson died in 2005, with the original implants still in place after 40 years of function.[148]

In the mid-1970s Brånemark entered into a commercial partnership with the Swedish defense company Bofors to manufacture dental implants and the instrumentation required for their placement. Eventually

an offshoot of Bofors, Nobel Pharma, was created to concentrate on this product line. Nobel Pharma subsequently became Nobel Biocare [148]

Brånemark spent almost 30 years fighting the scientific community for acceptance of osseointegration as a viable treatment. In Sweden he was often openly ridiculed at scientific conferences. His university stopped funding for his research, forcing him to open a private clinic to continue the treatment of patients. Eventually an emerging breed of young academics started to notice the work being performed in Sweden. Toronto's Professor Zarb, a Maltese dentist working in Canada, was instrumental in bringing the concept of osseointegration to the wider world. The 1983 Toronto Conference is generally considered to be the turning point, when finally the worldwide scientific community accepted Brånemark's work. Today osseointegration is a highly predictable and commonplace treatment modality [148]

Factors affecting osseointegration:

Various factors may enhance or inhibit osseointegration. Factors enhancing osseointegration include implant-related factors such as implant design and chemical composition, topography of the implant surface, material, shape, length, diameter, implant surface treatment and coatings, the status of the host bone bed and its intrinsic healing potential, the mechanical stability and loading conditions applied on the implant, the use of adjuvant treatments such as bone grafting, osteogenic biological coatings and biophysical stimulation, and pharmacological agents such as simvastatin and bisphosphonates [149]

Factors inhibiting osseointegration include excessive implant mobility and micromotion, inappropriate porosity of the porous coating of the implant, radiation therapyand pharmacological agents such as

cyclosporine, Amethotrexate and cis-platinum, warfarin and low molecular weight heparins, non-steroid anti-inflammatory drugs especially selective COX-2 inhibitors, and patients' related factors such as osteoporosis, rheumatoid arthritis, advanced age, nutritional deficiency, smoking and renal insufficiency [150].

Surgical techniques in dental implant

- One stage surgical protocol:This technique use non-submerged dental implant. No reopening of the surgical site at the prosthetic stage. The work of Ledermann suggested his protocol. The nonsubmerged implant placement and immediate loading of the implants in the anterior mandible.[149]

- Tow stage surgical protocol:In the early protocol of , submerged undisturbed healing was a prerequisite for successful osseointegration. This technique include the complete submerging of the dental implant for proper healing period 3-4 months in the mandible and up to 6 months in maxilla. The second stage of surgery is to uncover the imbedded implant to start the prosthetic procedure.[149]

Immediate loading [151]

The scientific literature is rife with definitions of immediate loading of dental implants. Misch et al., in 2004, 25 offered several classifi cations of implant loading:

- Immediate occlusal loading refers to full functional occlusal loading of an implant within 2 weeks of placement .
- Early occlusal loading refers to functional loading between 2 weeks and 3 months of implant placement .

- Nonfunctional immediate restoration refers to implant prostheses placed within 2 weeks of implant placement with no direct functional occlusal loading
- Nonfunctional early restoration refers to implant prostheses delivered between 2 weeks and 3 months from implant placement .
- Delayed occlusal loading refers to the restoration of an implant more than 3 months after placement.

Several factors determine whether a patient is a candidate for immediate loading of his or her dental implants. These factors can be divided into four categories:

.1 Surgery-related factors 2. Host-related factors

.3 Implant-related factors 4. Occlusion-related factors

The surgical factors pertain primarily to implant stability and surgical technique. Host factors include not only bone quality and density but also proper healing environment. Implant factors are based on the structure and design of the implant system utilized, and occlusal factors relate to the importance of proper prosthetic design under occlusal forces .

Delayed or staged occlusal loading.[152]

The occlusal loading to an implant restoration after a period of more than three months after implant insertion .

- Two stage delayed occlusal loading: The soft tissue cover the implant after initial placement .A second stage surgery after three month expose the implant to the oral environment .

- One stage delayed occlusal loading: The implant is position slightly above the soft tissue during the initial implant placement .

The implant is restored into occlusal load after more than three months.

Success and failure of dental implants:

Success criteria for endosteal implants have been proposed previously by several authors. The report by Albrektsson et al is widely used today. However, it does not consider the amount of crestal bone lost during the first year. In addition, success rates suggested in this guideline describe an ideal implant quality of health for a study or clinical report, but does not address individual implants that may have a stable condition in the mouth after a brief episode of bone loss. Implant clinical success, implant clinical survival, implant clinical failure. the survival rate, meaning whether the implant is still physically in the mouth or has been removed.[153,154]

In 1993, an implant quality of health scale was established by James and further developed by Misch. On 5th October, 2007, a Pisa, Italy Consensus Conference (sponsored by the International Congress of Oral Implantologists) modified the James–Misch Health Scale and approved 4 clinical category that contain conditions of implant success, survival, and failure. Survival conditions for implants may have 2 different categories: satisfactory survival describes an implant with less than ideal conditions, yet does not require clinical management; and compromised survival includes implants with less than ideal conditions, which require clinical treatment to reduce the risk of implant failure. Implant failure is the term used for implants that require removal or have already been lost [155,156]

CLINICAL INDICES:

Periodontal indices are often used for the evaluation of dental implants.[157,158] Periodontal indices, of themselves, do not define implant success or failure. These clinical indices must be related to other factors such as exudate or overloading of the prosthesis. However, understanding the basis of a few clinical indices for evaluation allows these criteria to establish a health-disease implant quality scale related to implant therapy

Pain: Once the implant has achieved primary healing, absence of pain under vertical or horizontal forces is a primary subjective criterion.

Mobility: Rigid fixation is a clinical term for implants, which describes the absence of observed clinical mobility with vertical or horizontal forces under 500 g, similar to evaluating teeth. The clinical term "lack of mobility" may be used to describe implant movement, and is a clinical condition most often used to determine as to whether the implant is integrated. A root-form implant supported prosthesis is most predictable with this type of support system. Lack of clinical movement does not mean the true absence of mobility. A healthy implant may move less than 75 m; yet, it appears as zero clinical mobility. However, when observed clinically, lack of mobility usually means that at least a portion of the implant is in direct contact with bone, although the percentage of bone contact cannot be specified.[159]

A clinically mobile implant indicates the presence of connective tissue between theimplant and bone, and suggests clinicalfailure for an endosteal root-formimplant. Implant "mobility" may be assessed by computer or various instruments.

Peri-implant Disease:The term peri-implantitis describes the bone loss from bacteriaaround an implant. Peri-implantitis is defined as an inflammatory process affecting the tissue around an implant in function that has resulted in loss of supporting bone.[160]

The ICOI Pisa Implant Quality of Health Scale is based on clinical evaluation. This scale allows the dentist to evaluate an implant using the listed criteria, place it in the appropriate category of health or disease, and then treat the implant accordingly. Three primary categories were established by the Consensus: success, survival, and failure. The success category describes optimum conditions, the survival category describes implants still in function but not with ideal conditions, and the failure of an implant represents an implant that should be or already has been removed. There are 4 implant groups to describe the clinical conditions of success, survival, or failure.