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Review Article

Eras of implants

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ABSTRACT

Here review highlights a brief, chronological sequence of the history of dental implants. Historical perspective begins with ancient civilizations and spotlights predominant dentists and their contributions to implant development through various ages of time immemorial. A dental implant (also known as an endosseous implant or fixture) is a surgical component that interfaces with the bone of the jaw or skull to support a dental prosthesis such as a crown, bridge, denture, facial prosthesis or to act as an orthodontic anchor. Chemical, physical and biologic properties of various dental implant surfaces and coatings include an overview of machined implants, etched implants, and sand-blasted implants.

1. Pre-historic era

"There's Gold (Ivory and Stone) in them thar (Implants)"!

The history of dental implants is a rich and fascinating travelogue through time. Dental implants have been used in one form or other to replace missing teeth since ages. Approximately since 2500 BC, the ancient Egyptians tried to stabilize teeth with the use of ligature wire made of gold. Etruscans customized soldered gold bands from animals to restore oral function in humans; about 500 BC ago. At about the same ages, the Phoenicians also used gold wire to stabilize teeth so these innovative people used teeth carved out of ivory which were then stabilized by gold wire to create a fixed bridge. The first evidence of attribution to dental implants goes to Mayan population, roughly around 600 AD they excelled in utilizing pieces of shells as implants or replacement for mandibular teeth. Radio graphically it was found that mandibles show compact bone formation around the implants-bone that amazingly looks very much similar like that seen around blade implants. Stone implant was first prepared and placed in the mandible in the early Honduran culture around 800 AD.[1]

Baglioni suggested that the mandible with skull had dental prosthesis. He claimed that dental plate around Rome in 1952 had a set of 12 sockets purported to hold teeth.[2]

Male skull found from the northern grave had bronze wire approximately 2.5mm in length firmly implanted in the canal of maxillary right lateral incisor which was dated to circa 200 BC. Zias and Numeroff suggests that a pin was drilled to hold an artificial tooth in place, or maybe drilled for a passage to drill out a large palatal cyst that is being identified at root of tooth.[3]

Etruscans customized soldered gold bands from animals to restore oral function, they also got replacement of teeth from oxen bone. Phoenicians used gold wire to stabilize teeth that were periodontally involved around 300AD, these

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innovative peoples used teeth creatively carved out of ivory which were then stabilized by gold wire to create a fixed bridge.[4]

Radiographs taken in 1970's of Mayan mandibles show compact bone formation around the implants bone that amazingly looked very much like that seen around blade implants. Around 800 AD stone implant was first prepared in mandible in early Honduran culture. Implant was attached to the adjacent tooth with special wires or devices. Gallo-Roman period dental implants were found during first or second century AD from necropolis at Chantambre in Essone, France is merely the most recent of this log list.[5]

2. From Rocks to Roosters- Early Implants Emerge

During 1500's to 1800's, teeth in Europe were collected from the underprivileged or cadavers and were used as allotransplants. Dr. John Hunter was able to observe and document with great detail the anatomy of mouth and jaw after working for many years with "resurrectionists"- In the 1700's, Dr. Hunter suggested transplanting teeth from one human to another; his experiment involved the implantation of an incompletely developed tooth into the comb of a rooster. He observed an extraordinary and astonishing event, the allotransplant tooth became firmly embedded in the comb of the rooster and the blood vessels grew into the pulp of the tooth.[6] In 1809, J. Maggiolo inserted a gold implant into a fresh extraction site. Site got healed, a crown was later added; unfortunately, there was extensive inflammation of the gingiva which followed the procedure. Innumerable substances were used as implants; these included silver capsules, corrugated porcelain, and iridium tubes.[7]

3. Brothers Strock to Building Spirals

Dr. EJ Greenfield graduated from Chicago college of Dental surgery in 1899 then practiced in Wichita Kansas, he recognized the limitations of natural tooth implantation and started artificial hollow cylinders made of iridioplantinum wire soldered with 24 karat in 1913. He placed a 24 guage hollow latticed cylinder of iridoplantium soldered with 24 karat gold as an artificial root to "fit exactly the circular incision made for it in the jaw-bone of the patient.[8]

In the 1930's, two brothers, Drs. Alvin and Moses Strock, experimented with orthopedic screw made of Vitallium (chromium-cobalt alloy). They observed that physicians successfully placed implants in the hip bone, so they implanted in both humans and dogs to restore individual teeth. Vitallium screw provided a good anchorage thus replacing missing tooth. These brothers were acknowledged as they selected a biocompatible metal to be used in the human dentition. The Strock brothers were considered as first to place the first successful endosteal (in the bone) implant. Incidentally, Dr. Alvin Strock also established the use of antibiotics for shipboard treatment of periodontal infections like trench mouth along with implants.[9]

In 1938, Dr. P.B. Adams patented a cylindrical endosseous implant that has threads both internally and externally; along with smooth gingival collar and a healing cap.[10]

Formiggini ("Father of Modern Implantology") and Zepponi in the 1940's developed post-type endoosseous implant. Spiral stainless steel design allowed bone to grow into the metal by constructing a stainless steel wire on itself. Dr. Perron Andres from Spain modified Formiggini's spiral design he used a solid shaft in the construction.[11]

4. Implant Discovery Continues… The Fabulous Forties and Fantastic Fifties

Dr. Raphael Chercheve[12] from France innovated the spiral design by creating burs for easyinsertion of the implant for a best fit. As the progression of implants continued, the subperiosteal (on the bone) implant was developed in the 1940's by Dahl in Sweden. Dahl's original implant involved flat abutments and screws that lay over the crest of the alveolar ridge. Gershkoff and Goldbergas well as Weinberg[13] in the United States from 1947-1948 produced a cobalt-chromium-molybdenum implant which was an extension to Dahl's design which included external oblique ridge. Lew, Bausch and Berman in 1950 researched and elaborated subperiosteal implant design.[14] In the 1950's, Dr. Bodine[15] observed several patients in the armed forces but the framework design was now more streamlined and he found that fewer struts or girders were needed. The holes for the screws were located in areas with the greatest bone strength and thickness. Dr. Lee introduced the use of an endosseous implant with a central post.

Finally, in the year 1951 Gottileb S. Leventhal of Philadelpia,[16] strongly recommended titanium as an ideal metal for use in fixation of bone fractures. As titanium was superior in characteristics with regard to tensile and yield strength, weight resistance to corrosion, ability to be welded and forged because it could be machined like stainless steel. Leventhal placed screws in rat femurs microscopically it was observed bone structure revealed no reaction to implants. Later this phenomenon was termed osseointergration by Branemark.

5. Increase of Implant Innovation: 1960's-1970's

Branemark discovered "Osseointegration" in 1969 when he observed that piece of titanium embedded in rabbit bone became firmly anchored and difficult to remove. After one year no inflammation was detected while soft tissue has formed an attachment to metal and bone to titanium. The branemark implant system was introduced in 1971.

Various implant designs emerged in the 1960's. Dr. Cherchieve[17] designed a double-helical spiral implant made of cobalt and chromium. These were screw-shaped and in a

single piece. Dr. Giordano Muratori further enhanced spiral shaft by the addition of internal threading to the shaft of the implant.[11] Dr. Leonard Linkow in 1963 designed the basic spiral design was was turned into a flat plate with various configurations. In 1967 Linkow introduced two variations in blade implant which were introduced making it possible to place it in either the maxilla or the mandible. Linkow developed the Ventplant implant.[18] The blade implant was now recognized as an endosseous implant. Dr. Sandhaus in the mid-60's developed a crystallized bone screw made up of aluminum.[19]

During 1970's, doctors Roberts and Roberts[11] began with the development of the Ramus Blade endosseous implant. It was made up of surgical grade stainless steel; according to them, it was going to serve as a "synthetic third molar". They developed the ramus frame implant which was anchored in the ramus bilaterally as well as in the symphysis area thus providing stability to implant system. Grenoble brought in the placement of vitreous carbon implants during 1970's.[20] Weiss and Judy[21] made popular the use of intramucosal inserts which helped in the retention of removable maxillary prostheses. Dr Small[22] in 1975, placed an implant device through a submental incision and attached to the mandible which was later known as the first transosteal implant called the mandibular staple implant. Thus helping those individuals with atrophic edentulous mandibles.

6. Splendid Serendipity with Splendors

In 1978, Dr. P. Branemark presented a two-stage threaded titanium root-form implant system using pure titanium screws termed as fixtures. He placed these implants in 1965 in patients. In 1952 Branemark discovered accidently that titanium placed in chambers over time became firmly anchored to the bone and could not be removed. The bone actually bonded to the titanium surface. His chance discovery was a huge realm in dentistry. So he termed the new concept of "osseointegration". Branemark later defined in a more refined way i.e direct structural and functional connection between ordered, living bone, and the surface of a load carrying implant". The original Branemark implant was cylindrical in shape, later on his innovation was somewhat tapered. Other implants introduced after the Branemark implant were the ITI-sprayed implant, the Stryker implant, the IMZ implant and the Core-Vent implant

7. Eighties Era

Dr. Schroder and Dr. Straumann of Switzerland were another ground breaking persons of implantology. They experimented with metals utilized in orthopedic surgery to help fabricate dental implants. In 1982, Dr. Zarb G[23] organized the Toronto conference on osseointegration in Clinical Dentistry. Till now research was almost 30 years and results were almost 20 years old this was first conference at north America in which implants has shown a success rate. A new idea of placing four to six implants in the front region emerged which was placed on a screw retained denture. These implants were evaluated for any movement which could be the result of bone loss around the implants. In the 1980's tapered shaped implants were available thus creating a wedging effect into the bone. Thus allowing better initial stability especially in less dense bone. Vent holes were introduced to improve osseointegration.[24,25]

Various factors were chosen over design for endoosseous implant system are the surface roughness, prosthetic considerations, ease of insertion into the bone cost and how successful they were over a period of time.

Dr Tatum[26] introduced the omni R implant in early in 1980's. DrNiznick introduced the core-vent implant in early 1980's. Implant was like a hollow basket with a threaded piece that helps to engage the bone. Hydroxyapatite coating implants were manufactured by him which allows immediate adaptation to the bone. He also invented other implant systems the Bio-Vent and Micro-vent.[27]

Dr Driskell in 1980's introduced the Stryker 'root form' endosseous implant made up of titanium alloy and another coated with hydroxapatite.

Dr Kirsch introduced the IMZ implant at the end of 1970's which was later on used in many countries in 1980's. It has disparate features i.e. titanium surface spray and intra –mobile element to duplicate the mobility of natural teeth.[28]

In 1985 integral implant system was introduced by the Straumann company. Later on nobelpharma introduced self-tapping implants in 1983. Company continued with future modifications and developments.[29]

Creekmore and Eklund[30] in 1983 started working with small size bone screws known as mini-implants known in orthodontics as temporary anchorage devices(TAD;s) used for anchorage for elastics. TAD's are used for intrusion, distalizing molars and for open bite closure. Nobelpharma saw the potential in Procera and acquired the technology in 1988 which was developed by Dr Matts Andersson. Introduced into market in 1989 after gaining approval from Swedish National Board of Health.[31]

8. Nineties Era

Andre Schroeder was another pioneer in implant dentistry, he taught the professionals that dental implants need not to be submerged at the time of surgery, the concept of non submerged implant developed. Crestal incisions were now more common than vestibular incisions. Concern about cleansibilty and ease of hygiene with mucosal margins around implants, arouse among periodontists so techniques were developed concerning the importance of attached gingival and maintenance of the implants.[32]

The development of modern ceramics was started in 1992 when companies have started manufacturing ceramic like implants for enhancing osseointegration. PolyEtherEtherKetone (PEEK) has shown promising results as it has osseontegration through osteoconduction. However due to diminish radiopacity it was a matter of concern.

Surface was roughened to create microporosities so that bone cells can better attach to implant surface. Now to gain height or width of bone various bone grafting augmentation techniques were introduced using autograft or allograft covering with semi-permeable membrane.[33]

9. Modern Era

Researchers have developed a variety of implant designs and surfaces thus providing a wide range of prosthetic options. Various researches are still going on to improve better dental implant materials and analysis techniques are still required to improve the outcomes.

10. Biohorizon Implant System

10.1. Laser–lok technology[33,34]

Laser ablation is used to create a micro channels in a circumferential channels which are précised. These micro channels are used to attach both osteoblasts and fibroblasts.

10.2. Nobelreplace tapered groovy implant[35]

It is shaped to resemble a tooth root. Since bone forms more rapidly in the grooves so integration takes at faster rate. This tapered design makes surgical procedure simple and predicatable.

10.3. Nobelspeedy implant[36]

TiUnite surface provides accelerated osseointegration. It narrow tip makes it perfect for flapless surgery.

10.4. Nobelactive implant[36]

Nobelactive Implants gently press through it like a corkscrew. It has narrow neck to preserve marginal bone and promote long-lasting soft tissue stability. These implants are useful in sites where vital anatomical structures are in close proximation.

10.5. Astra tech implant system[37]

Osseoe speed titanium surface is chemically modified thus providing nanotopograpy, this surface helps in increased in bone formation and stronger bone to implant bonding.

Conical seal design conical connection is below the marginal bone level transfers the load into the bone.

Straumann SL active implant SLA[38] implant surface is chemically modified sandblasted, large grit, acid - etched implant surface. Osteoblast activity starts within the first weeks thus angiogensis and bone healing within the first days.

10.6. Zygomatic implants[39]

Due to lack of sufficient bone volume, in posterior maxilla these implants are especially viable option in the rehabilitation of atrophic maxillae.

10.7. Surgical guides

Surgi Guides are fabricated through the process of stereolithography as surgi guides are computer –generated drilling guides. SimPlant software is used for implant positioning. Diameter of drilling tube is usually 0.2 mm larger than corresponding drill.

11. CAD/CAM Custom Implant Abutment Systems[40,41]

11.1. The procera system (Nobel Biocare)

Custom abutments are made up of titanium, alumina and zirconia. A scanned and custom abutment is designed by a 3D cad pro-gram. Pattern is removed from master cast and scanned by Procera scanner. Abutment can be digitized and a titanium or ceramic coping is produced.

11.2. All on four[42]

All on four is used in edentulous jaws so that maximum amount of available bone is utilized and thus allowing immediate function. This includes either conventional flaps or nobelguide helps in using flapless technique it has computerized planning and thus correct drilling and positioning the implants.

Properties of the implant has been altered using chemical alterations either inorganic addition (hydroxyapatite or calcium phosphates) or organic additions (growth factors) is being done.

Both cases, goal is to impart direct bone to implant contact. Various methods are done to increase surface roughness i.e. machining, acid etching, plasma spraying, machine grit blasting, laser treatment, anodization, coating, ion implantation, bio mimetic agents.

12. Current Implant Design Trends

12.1. Computer aided design and computer aided manufacturing technology[43,44]

Implants and abudments fabrication use CAD/CAM techniques. More accurate and less time consuming.

12.2. Nanotechnology based implants[45]

It contains surface roughness on nanoscale level to promotes protein adsorption and cell adhesion**.**

12.3. Functionally graded materials[46]

They are gaining attention in dental implant application. FGM is heterogenous composite material that includes a number of constituents exhibiting a compositional gradient from one surface of material to another. This design creates an optimized mechanical behavior and improves biocompatibility and ossesintergration.

12.4. Platform switching[47]

Interface between abutment and implant or the microgap is subject to micromovement and bacterial seeding, and thus it lies at or below the crest of the bone, prompts osseous resorption for those reasons. Alternative design for two stage implant is platform switching which is achieved by aligining a relatively wide implant platform to a comparatively narrow abutment and medialize the microgap, thus removing the interface from direct contact with the bone.

12.5. Immediate extraction and implant placement[48,49]

Immediate implantation has provided implant dentistry the opportunity to achieve better and faster functional and esthetic results. Rationale behind implant placement in fresh extraction socket is the preservation of soft tissue esthetics, reduced time and cost for patient.

12.6. Mini implants[50]

Mini dental implants (MDI) are titanium alloy implant screws that are ultra small in diameter i.e. 1.8 mm wide. These implants come handy in clinical situations where acceptable and satisfactory function cannot be achieved with conventional prosthesis.

12.7. New frontiers in implant dentistry research

Bioengineering, tissue engineering and nanotechnology are expected to revolutionize implant dentistry in a dramatic way over the next two decades. Arrival of nanotechnology has opened up new opportunities for development and manipulation of implant surface topography.

13. Conclusion

Implantology is a dynamic science which is under the process of improvisation. Titanium surfaces are roughed to provide predictable mode of therapy. Improvents at every stage, right from diagnosis, imaging modalities, treatment planning, grafting materials and techniques and implant design have made it possible to restore the missing dentition. Esthetics being the need of hour, implants with ceramic coatings, ceramic abutments and zirconia abutments have come for particular restoring the high esthetic zone.

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The authors declare that there is no conflict of interest

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