Review article

Implant Dentistry- Transitioning into a New Niche

Ayesha Shaziya Jubapu,[1] Erum Zain,[2] Kiran Rehman [3]

[1]Prosthodontics, Dubai Health Authority, Dubai, United Arab Emirates.
[2]Faculty of Dentistry, SEGi University, Selangor, Malaysia.
[3]School of Dentistry, International Medical University, Kuala Lumpur, Malaysia

Abstract

Implant dentistry has grown leaps and bounds over decades and currently it is at an unprecedented peak. Especially this decade has witnessed huge leaps forward in techniques, technologies, materials, concepts and philosophies of implant treatment. In less than just a few decades, dental implants have moved from the fringes of dentistry to the mainstream. Indeed, dental implants are now utilized in situations not foreseen even a decade ago. We need to reflect on the many significant developments in dental implants technology which offer better and a more satisfying treatment option to our patients. This article reviews the merits of current technologies as well as throws light onto the future of the implant speciality.

Keywords: Dental Implants, Zirconia, Surgical Guides

Corresponding author: Dr. Ayesha Shaziya Jubapu
Email: asdenticojubapu@gmail.com

Introduction

As one of the dental specialities, implantology has a long history of innovation and adaptability. Over its long history, it has proven to be a remarkable and innovative branch as it has evolved and responded to the expanding and ever more sophisticated patient needs and new technologies. For decades complete dentures, fixed partial dentures and removable partial dentures were the only treatment modalities available for treating partial or complete edentulism. More than 40 years ago, the advent of endosseous dental implants created a paradigm shift regarding tooth replacement options for patients and it is now considered a well-established treatment modality for partial or complete edentulism.[1]

Implant dentistry has grown leaps and bounds over decades and currently it is at an unprecedented peak. Especially this decade has witnessed huge leaps forward in techniques,

technologies, materials, concepts and philosophies of implant treatment. The entire scope of treatment has progressed originally from tooth replacement to surgically oriented implant reconstruction to the current and more correct prosthetically driven approach to the sophisticated arena of rehabilitation of the stomatognathic system.[2 3]

In less than just a few decades, dental implants have moved from the fringes of dentistry to the mainstream. Indeed, implants are now utilized in situations not foreseen even a decade ago. We need to reflect on the many significant developments in dental implants technology to offer better and a more satisfying treatment option to our patients. This article details the merits of current technologies as well as throws light onto the future of this speciality.[4]

A peek into the latest trends

Immediate Implantation with Immediate Temporization

The original Brånemark protocol published in 1977 influenced implant surgical technique and timing for years. It required that implants be submerged under the soft tissue for at least 4 months and discouraged load during the healing period. As more research accumulated, so did the evidence for unsubmerged implantation (i.e, placement of a transmucosal healing abutment). Barring the need for grafting, one-stage fixture placement is not only acceptable clinically but also easily accepted by patients, as it prevents the need for an uncovering surgery. This decreases the surgical experiences for the patient and minimizes chair time. Another time-saving surgical change is immediate temporization and immediate loading of dental implants within 48 hours of surgical implant placement.[5,6] Case selection can be a thorny issue for these cases. Typically, immediate loading is non-occlusal, that is, non-functional temporization. The interim restoration placed should not occlude with the existing dentition.

It must be noted that hours of judicious multidisciplinary diagnosis, planning, discussion, and laboratory work prior to the surgical appointment are needed, regardless of the corporate protocol used. In the end, case selection becomes the limiting factor. The patient requires a favorable occlusal scheme, sufficient bone to ensure primary stability, good health and a lack of parafunctional habits, among other traits.[7] There is a trend in the direction of this treatment. While early results are promising, this protocol is currently accepted as the standard of care.

Current Augmentation Methods

The most critical advancement for implant dentistry concerned a philosophical reversal. All too often, restorative dentists were left frustrated by non-favorably placed implants. “Well, that

is where the bone was," was a frequent refrain. Surgeons based implant positioning on the location or availability of the bone, for osseous grafting techniques were in their infancy. Today, this is not the case. The high predictability of current augmentation methods (i.e., block grafting, guided bone regeneration (GBR), sinus elevation) allows for implantation based on prosthetic desires instead of biologic limitations Thus the treatment goal targets the ideal reconstruction of the dentition. For the vast majority of cases, no compromises founded on anatomy need be made. Significant amounts of horizontal and vertical bony dimension is able to be achieved with GBR. GBR has been shown to equal intraoral onlay grafting with respect to the amount of bone regenerated. Additionally, investigations do not demonstrate resorption of or lower implant survival in regenerated bone over time, when comparing GBR to onlay grafting. Block grafts are not by and large superior to GBR; the evidence simply fails to support that statement.[8]

Abutments

Abutment fabrication has and continues to undergo significant metamorphosis. Many abutment options exist: standard machined titanium, standard machined gold, standard ceramic, custom made gold abutments (eg, UCLA) and computer-aided design/computer-aided manufacturing (CAD/CAM) titanium abutments.[9] From a practical stance, implant success criteria include not only stability and function but also esthetic harmony. Depending on the tissue thickness, implant location, and bone level, a standard titanium abutment may appear gray through the mucosa. One solution involves use of abutments constructed from gold or ceramic. In certain cases, the soft tissue will appear healthier and more esthetic. Improved appearance in the presence of a thin mucosa is the goal.

If the implant angulation falls short of ideal, a prefabricated straight or angled abutment may not compensate for off-axis orientation.[10] Custom-made abutments, whether processed by the clinician or industrially, ease the restorative procedure and perfect results. Technology exists that reduces clinical work but still generates an abutment tailored to the individual.

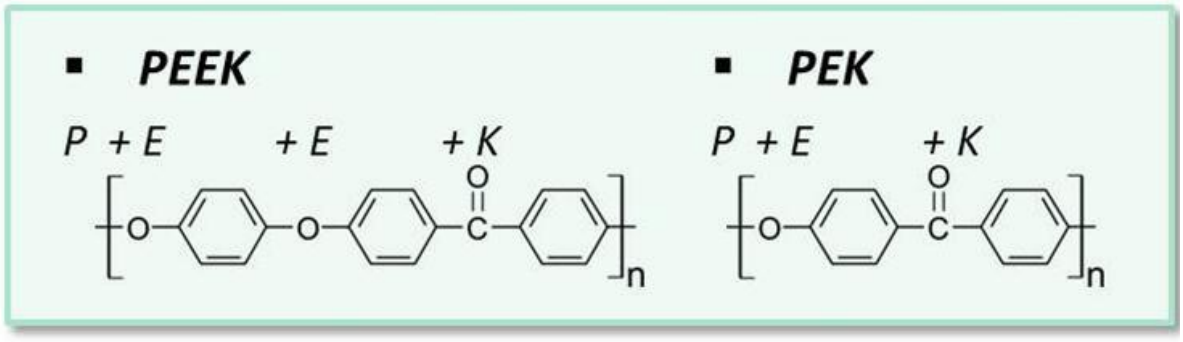
Zirconia Implants

In recent years, high strength zirconia ceramics have become attractive as a new material for dental implants. They are considered to be inert in the body and exhibit minimal ion release compared with metallic implants. Yttrium-stabilized tetragonal zirconia polycrystals appear to offer advantages over aluminum oxide for dental implants because of their higher fracture resilience and higher flexural strength. Zirconia seems to be a suitable dental implant material

because of its tooth like color, mechanical properties, and therefore biocompatibility. Apical bone loss and gingival recession associated with implants often uncover portions of the metal implant, revealing a bluish discoloration of the overlying gingiva. The use of zirconia implants avoids this complication and accedes to the request of many patients for metal-free implants. The material also provides high strength, fracture toughness, and biocompatibility.[11] The inflammatory response and bone resorption induced by ceramic particles are less than those induced by titanium particles, suggesting the biocompatibility.[12] Although zirconia may be used as an implant material by itself, zirconia particles are also used as a coating material of titanium dental implants. A sandblasting process with round zirconia particles may be an alternative surface treatment to enhance the osseointegration of titanium implants.[13]

Zirconia Implants

Peek (Polyether Ether Ketone) Implants



Following confirmation of its biocompatibility two decades ago, PEEK was increasingly employed as biomaterial for orthopedic, trauma and spinal implants. PEEK is a relatively new family of high temperature thermoplastic polymers, consisting of an aromatic backbone molecular chain, interconnected by ketone and ether functional groups. The

chemical structure of polyaromatic ketones confers stability at high temperatures (exceeding 300°C), resistance to chemical and radiation damage, compatibility with many reinforcing agents (such as glass and carbon fibers) and greater strength (on a per mass basis) than many metalsBy the late 1990s, PEEK had emerged as the leading high-performance thermoplastic candidate for replacing metal implant components, especially in orthopedics and trauma. In 1992, PEEK was used for dental applications, first in the form of esthetic abutments and later as implants. Since then many variations in the composition have been carried out to modify and improve upon the working characteristics of the implant. The implants used in had a combination of a phase specific tricalcium-phosphate and titanium dioxide contained within a PEEK matrix. While 80% of the composite was made of PEEK, 20% constituted of beta tricalcium phosphate and titanium oxide combined.

The isoelasticity of PEEK composites ensures that they warp identically to bone and thus produce a more homogenous distribution of stress along the implant bone interface.

Peek Implant

Titanium Zirconium Alloys

The need for increased mechanical strength from biomaterial implants, both in dental and orthopedic applications, has motivated the search for Ti-alloy alternatives that are free of toxic elements such as vanadium. In dentistry, the use of small diameter implants would be advantageous in situations where single teeth are being replaced or when implants need to be placed within narrow edentulous ridges. However, their use has so far been limited to the "esthetic zone", due to risk of fatigue fracture under high loading. A higher mechanical strength Ti-alloy for small diameter implants would obviate the need for reconstructive surgery and/or

bone grafting or augmentation in the narrow ridges. The titanium-zirconium (TiZr) alloys present as a promising candidate for such applications. [14]

PLATFORM SWITCHING

The interface between the abutment and implant, or the microgap, is subject to micromovement and bacterial seeding, and if it lies at or below the crest of the bone, prompts osseous resorption for those reasons. An alternate design for the two-stage implant is platform switching, which is achieved by aligning a relatively wide implant platform to a comparatively narrow abutment and medializes the microgap, thus removing the interface from direct contact with the bone. With possible movement and infection compartmentalized more or less to only the soft tissue, less crestal resorption results. Clinical studies that employ this implant–abutment configuration observe reduced vertical bone loss, even after function. Although a concept that garnered investigation only recently, platform switching data accumulates and shows potential.[15]

MINI DENTAL IMPLANTS (Mdis)

Every dentist has experienced the problem of dealing with patients with atrophic ridges. The patients always return with complaints of instability of dentures. This problem is more pronounced in the mandibular arch. Traditional dental implants require a period of healing and tissue integration in a nonloaded capacity for optimum predictability. The mini dental implant system (MDIs) can be immediately loaded and provides ongoing stabilization. The advantage in use of MDIs is the minimally invasive, single stage placement procedure, which consists of turning the implant into the bone through a starting opening, but not a prepared bone site. Hence, there is no bone damage or bone wound during implantation. Bleeding and postoperative discomfort are reduced, and most importantly, healing time is shortened.

MDIs are ultra-small diameter (l.8 mm width), biocompatible titanium implant screws, conceived and designed over 20 years ago by a board-certified Manhattan dentist, Victor I. Sendax.

Taking into consideration all advantages of MDI (success rates, surgical technique, financial advantages, possibilities of immediate loading), it can be concluded that MDI are highly successful implant option for edentulous mandible. This fact should be taken into consideration

during prosthetic treatment planning, especially in narrow alveolar ridges and patients who are not able to withstand the costs of more expensive conventional implants of larger diameter.[16]

Mini implant (left) next to a traditional implant.

CAD/CAM In Implant Dentistry

CAD/CAM technology takes implant planning a step further, and enables fabrication of a surgical guide. The surgical guide directs the surgeon in the exact location and angulation to place the implant. There is a growing number of software programs that allow viewing and analysis of the 3D images and subsequent fabrication of a surgical guide. In the youth of implant dentistry, the treatment was surgically driven, meaning that the implant was placed according to the bone available at the time of surgery. This approach eventually proved erroneous, because many implants were placed in locations and angulations that made them difficult or impossible to restore. The evolution has led to a restoratively-driven approach, where the restorative dentist communicates the desired position and angulation via a surgical guide.

The future of dentistry is quickly approaching. Digital impression systems and CAMed models for tooth born restorations are rapidly expanding in the market. Virtual tooth libraries allow CAD/CAM of both provisional and final tooth-born restorations. Numerous implant companies have already designed abutments for compatibility with digital impression systems. Just on the horizon is virtual articulation and virtual tooth arrangement, thus completing the virtual realm of dental technology. It is clear that CAD/CAM technology has transformed all aspects of dentistry, including implant dentistry.[17]

CAD/CAM fabricated surgical guide

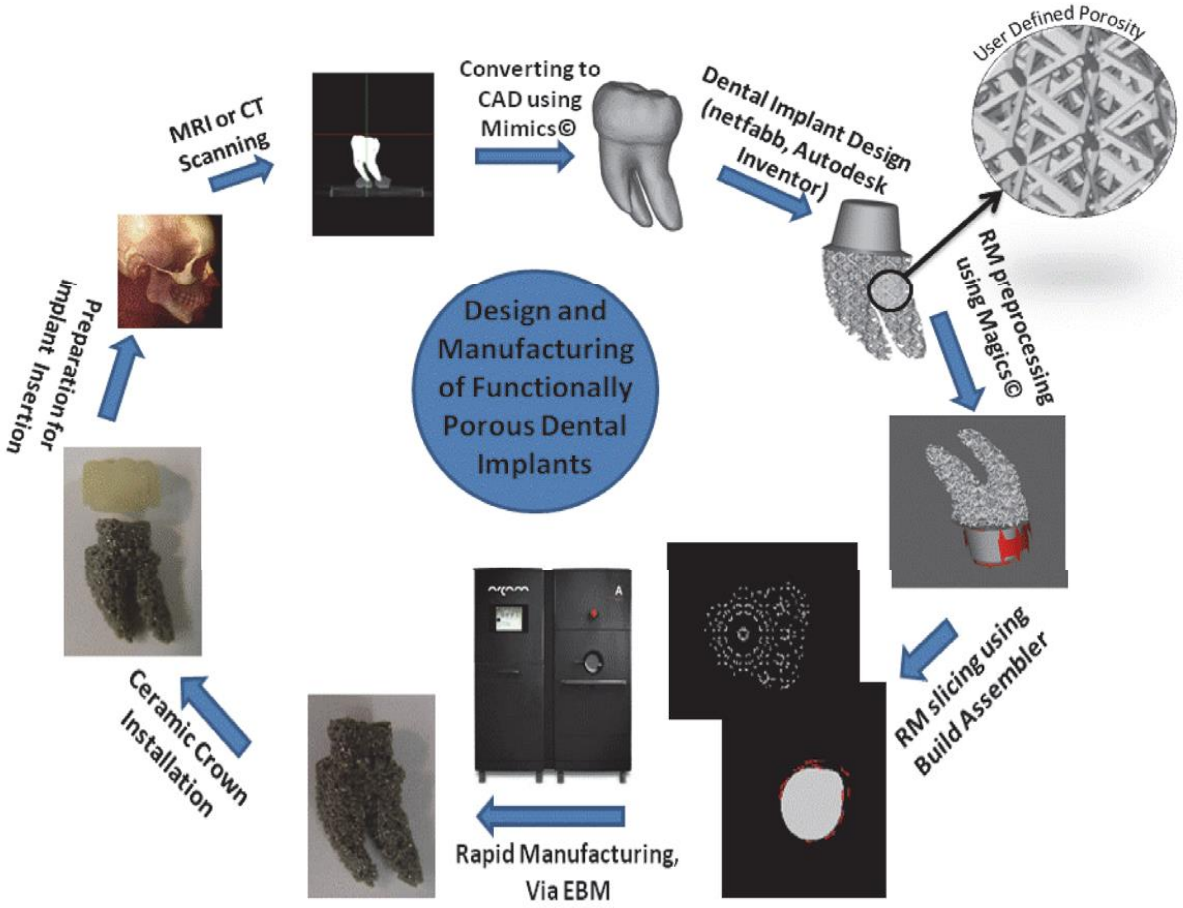
Tooth supported CAD/CAM fabricated surgical guide

Bioadaptable Dental Implants

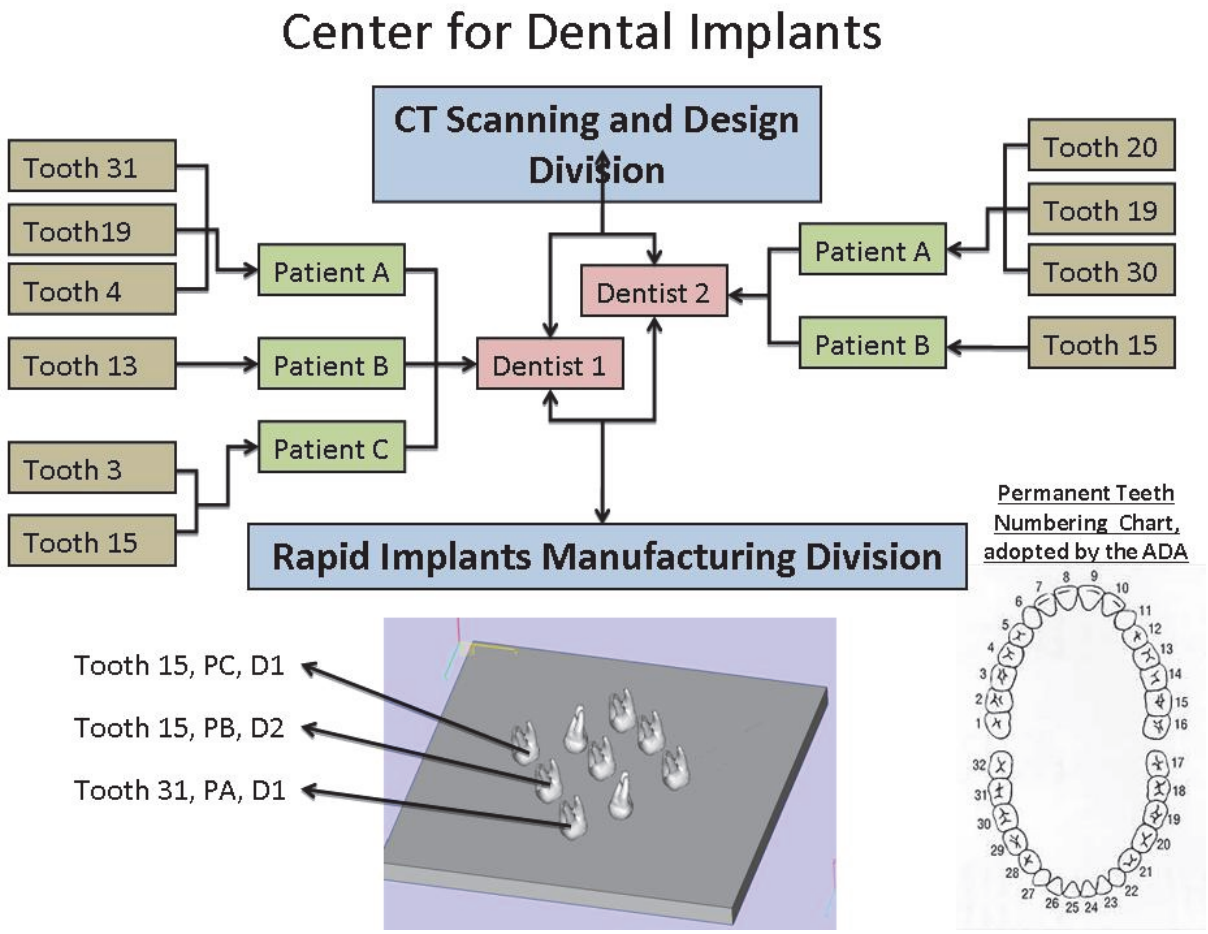
The concept of bio-adaptable dental implants was initially introduced as a customized root mimicking dental implant. By taking advantage of modern computed tomography (CT) techniques and the subsequent analysis capabilities of the scan data and the generation of three-dimensional computer models, in addition to additive manufacturing (AM) and its ability of producing application-specific parts, a cost and time effective track of designing and producing customized dental implants was devised.

The development of specialized software to generate bio-adaptable dental implant designs complying with patients' specifics can drastically reduce the already short lead time. From a clinical concept point of view, the insertion protocol of a bio-adaptable dental implant provides several advantages when compared to the traditional approach. The implantation is executed

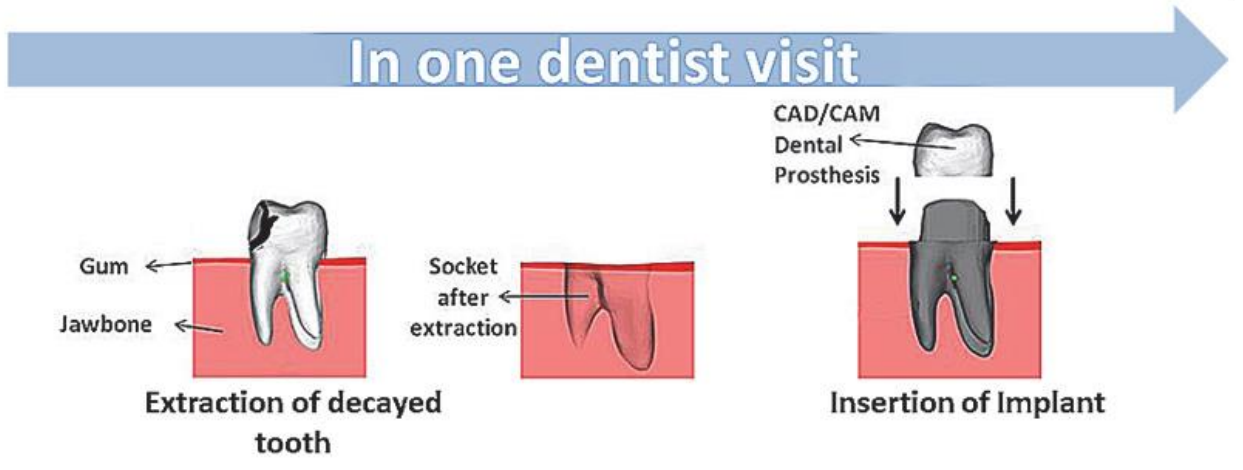
in one dental visit in contrast to the three visit protocol discussed earlier. The bio-adaptable implant is customized according to every patient and clinical situation; resultantly it provides optimal function and superior esthetics when compared to stock manufactured implants. In the case where CT scan banks are available, the implant can be ready upon the initial dental visit of the patient where the dentist can atraumatically remove the damaged tooth and insert the implant with minimal to no site preparation. Minimizing trauma will provide with faster healing of the surrounding bone. In addition, the immediate placement can provide immediate esthetics and function.[18]



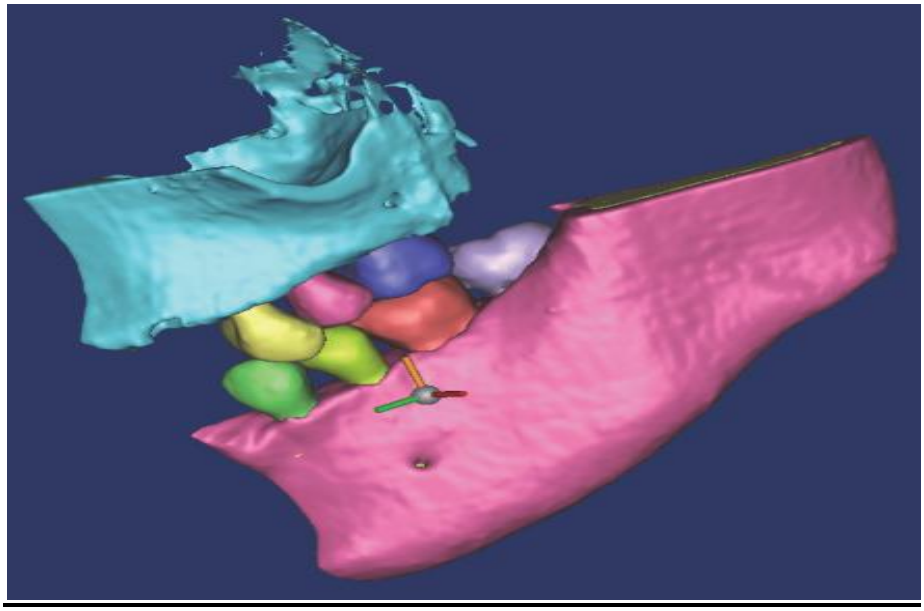
Design and production of a bio-adaptable dental implants.[18]



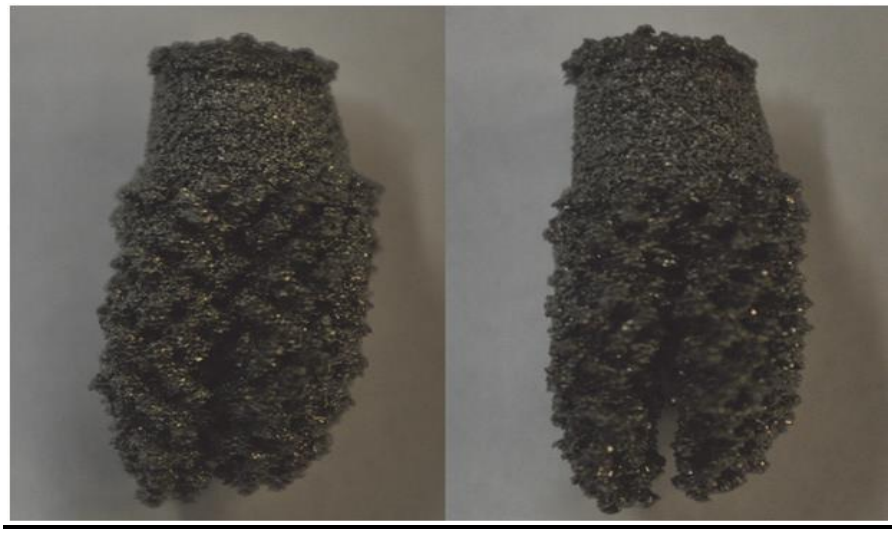
Mass production Concept of a bio-adaptable dental implant. [18]



Clinical concept of a bio-adaptable dental implant as a root-mimicking concept. [18]



Geometry of a patient's partial jaw extracted by means of CT analysis.[18]



Two bio-adaptable dental implants with porous rootform built by EBM. [18]

Potential advantages provided by the new concept include:

- Immediate restoration of function and esthetics
- Reduced treatment time
- No to minimally invasive site preparation
- Better bite feel due to micromotion capabilities
- Enhanced bone response
- Improved patient satisfaction, and quality of life

 Reduced health care cost

This concept is a new direction in implantology, where the implant matches the patient, instead of the contrary.

Surgical Simulation/Surgical Navigation Technologies

To facilitate safe and precise position of implants and avoid potential damage to the vital structures like the mandibular nerve and maxillary sinus two types of computer assisted surgeries are currently available.

As dental implants have become an established treatment, their application to aggressive cases with insufficient quantity and quality of bone has increased. To perform safe and precise surgery, overcoming these difficulties, computer-assisted systems have been developed. There are two major classes of these systems, that is, a computer-guided (static) system and a computer-navigated(dynamic) system.

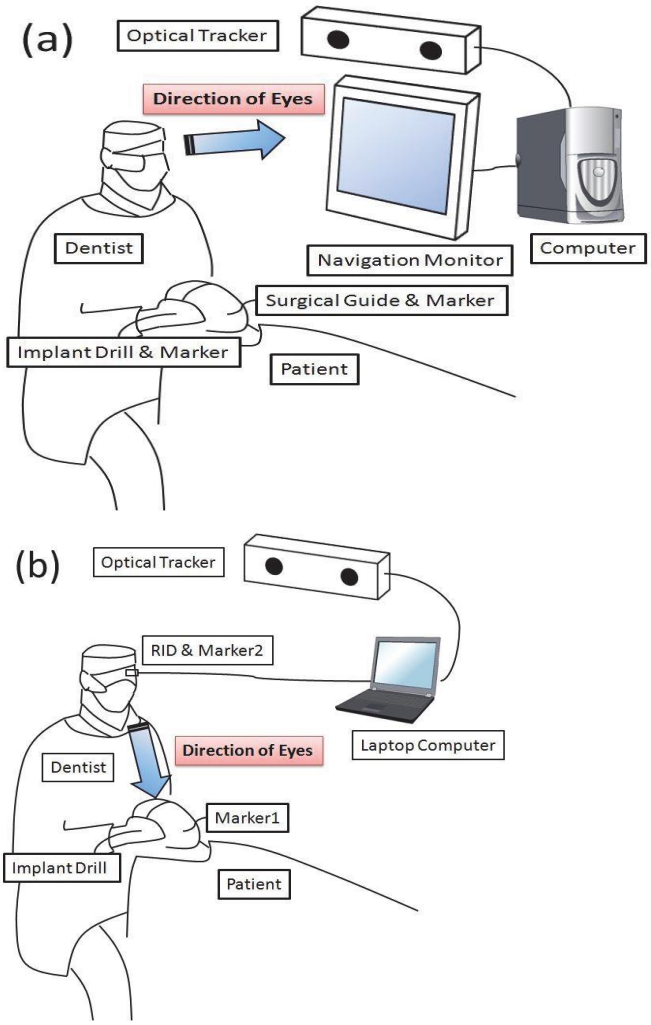
Computer guided or computer aided system –It is a surgical template based system which will optimally determine the position, direction, angulation, diameter and depth of implants.

Computer navigated system-It is an advanced form of computer assisted system with implant navigation. The technology offers high motion tracking technologies.

Augmented Reality with Surgical Navigation: Future Of Implant Dentistry

Augmented reality is defined as live direct or indirect view of the real physical world whose objects are modified, augmented or supplemented by computer generated sensory inputs such as graphics, sounds, videos etc. In other words, it enhances the person's current perception of reality by superimposing the virtual information onto the real time field.

Unlike an open chest surgery and an open abdominal surgery, looking away from the oral cavity intra-operatively involve a risk of operation errors in case of a dental implant surgery. However, with conventional systems, surgeons have to manipulate instruments in the patient's oral cavity while watching a surgical monitor and they feel anxious during operations. To overcome this problem, a novel surgical navigation system by combining the retinal imaging display (RID) or head mounted display (HMD)and the augmented reality (AR) techniques was developed.[19,20,21]



Schematic illustrations of a surgical navigation system for dental implantology. (a)Conventional approach: A direction of eyes of a dentist is directed to a navigation monitor.(b) Advanced approach: The direction of eyes of the dentist is directed to an oral cavity of apatient.[19,20,21]

Developments In Implant Imaging

Imaging has always been an important part of dental implant procedures from its beginning. More recently, in the last five years, a revolution is occurring with the availability of "cone beam" CT machines in dental offices and directly in dental surgery enables dentists to manage all the stages, from diagnosis, choice of imaging technique, generation and distribution of imaging data, implant planning, to surgical step. Nowadays radiologist takes place as a specialist in dental imaging, that pays attention to evolution of dental implant techniques.

Denta-scanner

It is a very accurate method of jawbone's exploration. It enables dentists to obtain morphological analysis of implant site and bone structure. The initial acquisition gives millimetric slices in axial plan with high resolution. They give different measurements as bone cortical thickness, and dental space.

Cone beam CT

It consists of a new device family using cone-shaped X-ray emission. It enables multiplanar reconstructions of dento-maxillary sphere.

The two principal softwares created for dental implant planification are called **Simplant and Nobelguide**, they are mainly designed for surgical act, and a work tool to show dental surgeon the way in implant installation called **Robodent**.

These technologies represent a real and very interesting progress.

As a conclusion, we can see that dental imaging has a major role in implant techniques, with noticeable precision and reliability in pre-implantal planification and surgical help.[22]

Value comparison of implant imaging modalities* commonly used to evaluate implant sites.†

IMAGING GOAL	TWO-DIMENSIONAL IMAGING SOURCES				THREE-DIMENSIONAL IMAGING SOURCES	
	Cephalographic	Periapical	Panoramic	Tomography	Computed Tomography	Cone-Beam Computed Tomography
Bone Height	1	3	2	3	4	4
Bone Width	0	0	0	3	4	4
Long Axis or Ridge	0	0	0	3	4	4
Anatomy Localized	1	1	1	3	4	4
Bone Quality	0	2	2	2	4	3
Pathosis Identified	1	2	3	2	3	4
Jaw Boundaries Determination	1	0	2	3	4	4
Virtual Planning	0	0	1	1	4	4
Guide Fabrication Facilitated	0	0	0	0	4	4
Communication Aid	2	1	2	2	4	4
Benefit/Risk/Cost Ratio	1	1	2	2	3	4

* The imaging modalities are ranked by their ability to satisfy implant planning imaging goals. Ranking scale: 0 = no value, 1 = low value, 2 = mild value, 3 = moderate value, 4 = high value.

† Adapted with permission of Journal of the California Dental Association from Hatcher and colleagues.[1]

Application of Lasers in Dental Implants

The parallels in the expansion of implant dentistry and laser dentistry in clinical practice are apparent. As advocates for laser dentistry continue to seek new ways to use the technology and as more practitioners become involved in implant dentistry, it is logical to see the concurrent use of both technologies in clinical practice.[23] Commonly used lasers in implantology include: Diode, Er:YAG, Er,Cr:YSGG, Nd:YAG, CO2

APPLICATIONS

- Second-stage surgery of submerged implants
- Removal of peri-implant hyperplastic overgrowths
- Treatment of peri implant lesions
- Decontamination
- Surface characterization of implants
- Sinus lift procedures
- Block grafting
- Implant placement

ADVANTAGES

- Dry and bloodless surgery
- Instant sterilization of the site
- Reduced bacteremia.
- Reduced mechanical trauma.
- Minimal post-operative swelling and scarring
- Minimal post-operative pain
- Lasers can achieve excellent tissue ablation with bactericidal and detoxification effects
- Less wound contraction
- Prevents the production of matrix-metalloproteanases (collagenase, gelastase, elastase, protease) which break down soft tissue, cause edema/erythema, and have an osteopromotive effect on osteoclasts.[23]

Stem Cells in Implant Dentistry

The recent increase in the demand for dental implants has generated a need for robust bone augmentation in the atrophic alveolar ridge and the maxillary sinus. The Academy of Osseointegration stated in its 2010 Silver Anniversary Summit that the continued improvement of the dental implant success rate will require stem cell-based technologies, as osteogenic stem cells in an implant osteotomy site could provide the necessary factors to form superior bone that could contribute to enhanced long-term success of the implant treatment. Such an approach would decrease the need for a GTR membrane and could be used as a single product without requiring other adjuncts. Stem cell therapy is also potentially important for patients with compromised vascular supply and impaired wound healing because it may be able to improve vascularity to facilitate hard tissue augmentation at local sites. Therefore, stem cells seem to present a promising strategy to achieve the regeneration of large alveolar bone defects, particularly to provide stable and accelerated bone formation as well as enhanced osseointegration in dental implant treatments.[24, 25]

Conclusion

Implant dentistry is also progressing rapidly today largely due to technological innovations. As we look ahead the future will definitely bring about more advances as our technological skills, research efforts and abilities improve. There are numerous areas for future developments in dental implants, hence it is reasonable to look forward to the further transformation of this industry from a complex, esthetic, surgical and functional dilemmas into simpler rehabilitation solutions.

References

1. John A. Hobkirk. Prosthodontics: A Past with a Future. J Can Dent Assoc. 2005; 71(5):326.
2. Dano D, Stiteler M, Giordano R. Prosthetically Driven Computer-Guided Implant Placement and Restoration Using CEREC: A Case Report. Compend Contin Educ Dent. 2018 May;39(5):311-317
3. Mandelaris GA, Stefanelli LV, DeGroot BS. Dynamic Navigation for Surgical Implant Placement: Overview of Technology, Key Concepts, and a Case Report. Compend Contin Educ Dent. 2018 Oct;39(9):614-621
4. Ring M E. Pause for a moment in dental history: A thousand years of dental implants: A definitive history - Part 1. Compendium. 1995; 16:1060-1069.

5. Seyssens L, Eeckhout C, Cosyn J. Immediate implant placement with or without socket grafting: A systematic review and meta-analysis. Clin Implant Dent Relat Res. 2022 Jun;24(3):339-351
6. Singh M, Kumar L, Anwar M, Chand P. Immediate dental implant placement with immediate loading following extraction of natural teeth. Natl J Maxillofac Surg. 2015 Jul-Dec;6(2):252-5
7. Tettamanti L, Andrisani C, Bassi MA, Vinci R, Silvestre-Rangil J, Tagliabue A. Immediate loading implants: review of the critical aspects. Oral Implantol (Rome). 2017 Sep 27;10(2):129-139
8. Mengel R, Eckert A, Greene B, Thöne-Mühling M. Implants in GBR-Augmented Sites in Patients Treated for Generalized Aggressive Periodontitis: A 10- to 20-Year Prospective Case Series. Int J Periodontics Restorative Dent. 2022 Mar-Apr;42(2):243-250.
9. Park JM, Lee JB, Heo SJ, Park EJ. A comparative study of gold UCLA-type and CAD/CAM titanium implant abutments. J Adv Prosthodont. 2014 Feb;6(1):46-52
10. Guguloth H, Duggineni CR, Chitturi RK, Sujesh M, Ravvali T, Amiti RR. Correlation between abutment angulation and off-axial stresses on biomechanical behavior of titanium and zirconium implants in the anterior maxilla: A three-dimensional finite element analysis study. J Indian Prosthodont Soc. 2019 Oct-Dec;19(4):353-361.
11. Gargallo-Albiol J, Böhm K, Wang HL. Clinical and Radiographic Outcomes of Zirconia Dental Implants-A Clinical Case Series Study. Materials (Basel). 2022 Mar 25;15(7):2437
12. Munro T, Miller CM, Antunes E, Sharma D. Interactions of Osteoprogenitor Cells with a Novel Zirconia Implant Surface. J Funct Biomater. 2020 Jul 16;11(3):50
13. Bacchelli B, Giavaresi G, Franchi M, Martini D, De Pasquale V, Trirè A, Fini M, Giardino R, Ruggeri A. Influence of a zirconia sandblasting treated surface on peri-implant bone healing: An experimental study in sheep. Acta Biomater. 2009 Jul;5(6):2246-57
14. Leo SJ, Tan MY, Yee SHX, Lee FKF, Tan KBC. Rotational Load Fatigue Performance of Titanium Vs Titanium-Zirconium Implant-Abutment Connections. Int J Oral Maxillofac Implants. 2022 Jul-Aug;37(4):740-747.
15. Salama AA, Katamesh HA, El Mahallawi O, Halim CH. The Effect of Platform-Switching Implants and Different Abutment Materials on the Stress Distribution of

Implant-Supported Restorations. Int J Periodontics Restorative Dent. 2020 Mar/Apr;40(2):285-291.

16. Wang B, Ho KS, Neo TK, Cheng AC. Mini-dental implants for definitive prosthesis retention - A synopsis of the current evidence. Singapore Dent J. 2019 Dec;39(1):1-9.
17. Chen P, Nikoyan L. Guided Implant Surgery: A Technique Whose Time Has Come. Dent Clin North Am. 2021 Jan;65(1):67-80.
18. Gilbert C, Pauline S, Radovan K, Raed A and Khaldoun A. Bioadaptable dental implants. Digital Engineering of Bio-Adaptable Dental Implants. Implant dentistry. 2011.
19. Lin YK, Tsai KL and Yau HT. The Development of Optical See-through Display Based on Augmented Reality for Oral Implant Surgery Simulation. Computer-Aided Design & Applications. 2012;9(1): 111-120.
20. Lin YK, Yau HT, Wang IC, Zheng C, Chung KH. A Novel Dental Implant Guided Surgery Based on Integration of SurgicalTemplate andAugmented Reality. Clinical Implant Dentistry and Related Research. 2013; 3:31-35.
21. Yamaguchi S, Ohtani T, Ono S, Yamanishi Y, Sohmura T and Yatani H. Intuitive Surgical Navigation System for Dental Implantology by Using Retinal Imaging Display. Implant dentistry –rapidly evolving practice. 2009.
22. Auboin ML, Ameur AA, Hauret L. Developments in implant imaging. Dental Implant Imaging:How CT Scan Became a Help to Surgery. Implant dentistry. 2011.
23. Convissar RA. Principles and Practice of laser dentistry. 1st edition.
24. Laino L, La Noce M, Fiorillo L, Cervino G, Nucci L, Russo D, Herford AS, Crimi S, Bianchi A, Biondi A, Laino G, Germanà A, Cicciù M. Dental Pulp Stem Cells on Implant Surface: An in Vitro Study. Biomed Res Int. 2021 Mar 23; 2021:3582342
25. Egusa H , Sonoyama W, Nishimura M, Atsuta I, Akiyama K. Stem cells in dentistry-Part II: Clinical applications. Journal of prosthodontic research. 2012;56(4):229-248.