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Current Trends & Concepts in Prosthodontics

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Abstract: ***Evolution happens in our everyday life in every field and prosthodontics is no exception to it. A new generation of patients are expected to have new aspirations and desires. In order to fulfil these desires it is our duty to be updated with both knowledge and skills about new trends in prosthodontics, so that these aspirations can be met with. This paper gives an insight about the various trends and concepts applied in the field of prosthodontics.***

Keywords: Stereolithograpy, Biomimetics, Tissue engineering, Stem cell therapy, Nanotechnology, Digital simile designing, virtual articulators, lasers, robotics, digital impressions, guided implant surgery, SDA concept, CB

1. Introduction

- Prosthodontics is a well defined and broad dental specialty catering to a wide range of oral rehabilitative treatment needs of community. It is continuously evolving consequent to the rapid advancements in dental biomaterials science, clinical and laboratory techniques and technologies.
- The dynamic nature of our specialty, its current trends, innovative thoughts, emerging technologies etc contributes to overall shaping the future of prosthodontics.[1]

Emerging trends in prosthodontics are seen in:

- CBCT
- CAD/CAM
- Optical scanning of teeth (Digital impressions)
- Guided implant surgery
- Rapid prototyping & Stereolithography
- Occlusal analysers-Tscans, myographic devices.
- Biomimetics
- Stem cell therapy
- Tissue Engineering
- Shortened dental arch concept
- Nanotechnology
- Electronic shade matching
- Digital smile designing
- Virtual articulators
- Lasers
- Robotics

All these technologies have various applications in various prosthodontics procedures.

Cone Beam Computed Tomography (CBCT)

Cone beam tomography is highly advanced form computed tomography where the X-rays are divergent, forming a cone. It has been designed to produce 3 dimensional images of the tissues of the maxillofacial region .[2, 3, 4]

CBCT in implants:

a) Used to assess bone-
   - Quantity- width and height of bone at implant site.
   - Quality -- thickness of cortical plate, trabecular pattern and relationship with any vital structure at the implant site.[4]

b) Can be used in nerve tracing and virtual implant postioning .

c) Computer-generated surgical guides (stereolithographic models) can be fabricated from the CBCT data.[2]

CBCT in temporomandibular joint imaging

CBCT images can be manipulated to derive three-dimensional volumetric images that can be viewed from any perspective with superimposing tissues dissected out to clearly visualize the region of interest. [5]

CBCT in MFP

Using CBCT Three-dimensional augmented virtual models of the patient's face, bony structures, and dentition can be created out of CBCT DICOM data. The shape of the graft can be virtually planned. In addition, implant placement onto the graft can also be planned. Obturators for cleft closures can be precisely milled in CAD/CAM units by using the data obtained from CBCT.[6]

Computer- Aided Design/ Computer- Aided Manufacturing (CAD CAM):

Recently CAD/CAM technology has been introduced to many fields of dentistry including the field of Prosthodontic dentistry. CAD/CAM in prosthodontics is used to design and creation dental prostheses, including crowns, crown lays, veneers, inlays and on lays, fixed bridges, dental implant restorations and in removable or fixed dentures.[6]

The available CAD/CAM systems can be divided into three groups based on their production methods.

- **In office system**: Where a dentist digitally scans the prepared tooth, creates restorations chairside, and then seats it within a single appointment
- **In laboratory system**: Where laboratories could scan models made from physical impressions and use CAD/CAM to produce restorations

- **Centralized production**: Where a dentist captures chairside digital impressions and then send data (satellite scanners) via the internet to the milling centre.[7]

All CAD/CAM systems have three **functional components**.

- A means of data acquisition (equivalent to traditional impression-making)
- Restoration design(CAD)
- Restorative production(CAM).[7]

Data Acquisition-Scanners:

- Scanners: Thedata acquisition is either performed directly in the patient's mouth (intraoral) or indirectly after taking an impression and fabricating a master cast (extraoral). Basically there are two different scanning possibilities
  1. **Mechanical scanners**: The master cast is read mechanically line-by-line by means of a ruby ball and the three-dimensional structure measured.
  2. **Optical scanners:** After completion of tooth preparation, tissues are retracted to visualize the tooth margins, tooth is dried then oxide powder is applied on the tooth to remove optical highlights & to enhance the scan quality and finally readied for scanning. Scanners use either a series of static images or a stream of video images to capture the geometry of the tooth preparation.[7, 8]

CAD/CAM IN REMOVABLE PROSTHODONTICS:

- The fabrication of complete dentures using a (CAD/CAM) system has the potential to simplify the process .
- In fabrication of a removable partial denture, the framework design is drawn on the working cast and then scanned using a laboratory scanner.
- The framework can be fabricated by printing a photo polymeric framework and then cast with chromium cobalt,
- Or the framework can be printed directly from chromium cobalt through Direct Metal Laser Sintering.[6]

CAD/cam in implant prosthodontics

- CAD/CAM allows simplified &precise production of durable implant components
- The CAD component virtually designs the 3D contour of the final implant component. The CAM system produces the actual implant component according to the virtual design.
- In implant dentistry, the implant abutments and frameworks are produced by milling at a central production facility.[6]

CAD/CAM in maxillofacial prosthodontics

- CAD/CAM is widely used for the fabrication of maxillofacial prostheses, extraoral radiation devices, individual respiratory masks and facial protection devices etc.
- Three dimensional surfaces imaging is done by using CAD software. This 3-D surface image aids in the fabrication of resin model with Lithographic technique and then wax pattern is made. Of this completed wax pattern, once again computer assisted three dimensional imaging is done. Data is entered in computer and prosthesis is milled by computer aided milling machine. Thus, a silicone maxillofacial prosthesis is fabricated using CAD/CAM technology.[6]

Rapid Prototyping & Stereolithography:

Rapid prototyping is a technique used to quickly fabricate a model or assembly using three-dimensional computer aided design data. Construction of this part is usually done using 3D printing or "additive layer manufacturing" technology

RP-applications in implant therapy:

Used to fabricate computer-generated surgical templates by a technology called stereo lithography. These guides/templates are fabricated by photo-polymerization of an ultraviolet sensitive liquid resin. This surgical template helps in positioning implants in terms of depth, angulation, and mesio-distal and bucco-lingual positioning accurately as planned during the 3D computer simulation.[10]

Rp-Applications in Maxillofacial Prosthodontics

- Production of auricular and nasal prosthesis
- Obturators
- Manufacturing of surgical stents
- Fabrications of burn stents, where burned area can be scanned rather than subjecting sensitive burn tissue to cumbersome impression procedures.[10]

Computer Guided Surgeries

Computer guided implant surgery is a surgical procedure in which the virtually planned implant position can be transferred to the patient and also may help to navigate the surgical procedure .[9]

Types of Computer Guided Implant Surgery Protocols:

Static methods:

- Employ static surgical guide that reproduces the virtual implant position directly from CT data
- It does not permit modification of the implant position during surgery.

Dynamic methods (navigation):

- Involves the use of a computer-guided navigation system that reproduces the virtual implant position directly from CT data and allows intra-operative changes of the implant position.
- It is based on motion tracking technology as it helps the clinician in real time bur tracking during the implant positioning (currently not particularly widespread as they require costly equipment and complicated advanced software)[9]

Occlusal Analysers-T Scans and Allied Myographic Facilities

T-Scan was introduced in 1988 by Dr. William Maness as an automated computerized sensor for analysis of the dental occlusion.[11]

T-Scan allows to effectively target truly problematic occlusal contacts, therefore effective in early diagnosis and treatment planning

- It registers the patients occlusion on a thin patented 60 µ thickness disposable sensor to record instantaneously the patient bite in terms of location, timing, and force of every tooth in contact.
- This record is then transferred to a computing system which can make an actual simulation of the patient occlusion on a monitor, assuming the different situations possible during centric, eccentric, and functional movements.[11]

Many improvements in the system (up to fourth generation) have been done, now allowing use of a 100 µ thin sensor and software to analyze and display the timing and force of the patients bite in 2D and 3D graphics.

Other Myographic Devices

- Jaw tracking devices (K7 Diagnostics)-helpful in studying jaw movements which in turn helps to assess occlusion that may be a micro-traumatic to the temporomandibular joint.
- An commercially available electromyographic device BITE STRIP™ can record muscle activity for 6 h which provides useful information in cases of nocturnal bruxism.[11]

Biomimetic Dentistry

The term "bio" means life and "mimesis" in Greek means imitate.

- Biomimetics -- is the field of study that attempts to design system and synthesize materials through biomimicry.[12]

Biomimetics in Fixed Prosthesis

Bioceramics commonly used for replacement of lost tooth structures (crown fabrication) . The common bioceramics that are used in dentistry are :

- **Alumina**--has very good corrosion resistance, high strength, and wear resistance.
- **Hydroxyapatite**--calcium phosphate-based ceramic material which is the major component of bone and teeth. [12]

Biomimetics in Implants

- Calcium phosphate hydroxyapatite and various types of alumina are highly biocompatible and stable in oral environment are coated onto the implants surfaces to enhance osseointegration
- Biomimetic Ca-P coating on load-bearing dental implants has been developed in order to take advantage of the superior mechanical properties of substrates and excellent biocompatibility of Ca-P materials.
- Presently, incorporation of therapeutic and bioactive agents into Ca-P coating is most preferred. Examples are Albumin, Bone morphogenic proteins (BMP-2 and BMP-7), Bisphosphonates, Antibiotics etc.[13]

Stem Cell Therapy

Stem cell therapy is an upgraded procedure that can be used for the treatment of degenerated tissues.[14]In stem cell therapy, cells of definite regenerative potential are administered into the necessary site in order to obtain new regenerated tissues.

Cells from various sources, such as articular cartilage cells, fibroblasts, human umbilical cord matrix stem cells, and mesenchymal stem cells, have been used in efforts to reconstruct the TMJ.[14]

Tissue Engineering

Involves developing in vitro and/or in vivo a biological replacement tissue that mimics the biological, morphological, and organizational characteristics of the tissue it is replacing. In this field stem cells have gained increasing popularity in the tissue engineering of joints and have been used by various investigators for developing prototype TMJ condyles.[15]

Shortened Dental Arch (SDA) Concept:

According to this concept, missing teeth is not necessarily the diagnostic criteria replacement. Many people can have an acceptable oral function with partial dentition, ie, anterior teeth and at least four occlusal units are adequate. [1]Hence while treatment planning, "no treatment" has become a viable treatment option, in which excessive treatment of an otherwise satisfactory dentition in both is esthetics and function is considered.

Nanotechnology

Nano is derived from the Greek word for dwarf. It is engineering at the atomic or molecular scale.[16]

Nanotechnology in prosthodontics

Impression materials such as vinyl polysiloxanes have been integrated with nanofillers which has better flow, improved hydrophilic properties & enhanced detail precision.
Example: Nanotech elite H-D.[16]

Nanotechnology in removable prosthodontics

- Incorporation of carbon nanotubes into heat cure monomer—reduces the polymerization shrinkage and improves the mechanical properties.
- Incorporation of metal oxide nanoparticles into conventional polymethyl methacrylate -improves the flexural strength, reduces adhesion of biofilm & has antimicrobial property and also reduces porosity.
- Nanocomposite denture teeth can be used which are stain and impact resistant with more lively surface texture.[17]

Nanotechnology in Fixed Prosthodontics

- Nanocomposites: Nanofillers are incorporated into the resin matrix led to the development of newer light cure composite with advantages as: Highest mechanical strength, low polymerization shrinkage, low thermal expansion, low water sorption, excellent marginal integrity & handling characteristics
- Nanofillers in nano-optimized moldable ceramics enhance polishability and reduce wear.
- Resin luting agents incorporated with nanomodifiers has improved mechanical properties.[17]

Nanotechnology in implants

a) Current trends in dental implant therapy include use of endosseous implant surfaces embellished with nanoscale topography.

b) This can modify surface of the implants to alter the cellular and tissue response of the host that benefit dental implant therapy.
c) Three nanostructured implant coatings in use –
   - Diamond (improved hardness, toughness, low friction)
   - Hydroxyapatite (increased osteoblast adhesion proliferation and mineralization)
   - Graded metalloceramics (ability to overcome adhesion problems)

d) Trade name – nanotite.[17]

Nanotechnology in MFP:

- In maxillofacial prostheses one of the main reasons for failure include mechanical failure due to lack of tensile strength to tearing loads.
- The use of polyhedral oligomeric silse squiox as a reinforcing agent, has enhanced the tensile and tearing strengths of conventional materials.[17]

Electronic Shade Matching:

Visual shade matching is now being overruled with automatic electronic shade selection devices such as **colorimeters, spectrophotometers, and digital imaging devices** as they provide more consistent shade and a more near-life like effect with color mapping of tooth selected.[7]

Colorimeters:

Colorimeters measure the tristimulus values, filtering light in the red, green, and blue areas of the visual color spectrum.[7]
Examples: The ShadeVison®ShadeEye NCC® (Shofu)

Spectrophotometers:

Measures and records the amount of visible radiant energy reflected or transmitted by an object, one wavelength at a time for each value, chroma, and hue present in the entire visible spectrum.[7]It is the most accurate instrument for shade selection in dentistry.
e.g:VITA EasyShade Compact®
CrystalEye®.

Digital Smile Designing

The digital smile design is a multiuse tool that assists the dentist throughout the treatment and increases the patients acceptance of the final treatment outcome.

The placement of references lines and over extra- and intra-oral digital photographs widens the diagnostic vision and helps to evaluate the limitations and esthetic principles of a given case.

Various software available includes Smile Designer Pro, Visagismile, Digital Smile Design, Planmeca Romexis® Smile Design, 3Shape Smile Design, Photoshop CS6, Keynote.[7]

Virtual Articulators and Digital Facebows

The digital facebow is developed to provide an alternative to the conventional facebow for the mounting of casts to an articulator. It implements several design features in order to prevent or minimize errors and by doing so provides more accurate mounting and reinforces the anatomical considerations associated with articulators.

A virtual articulator simulates jaw motion which is used to design the virtual crown and other prosthesis. By using a virtual articulator the technician can reduce the error of design and make a good prosthesis for patient with simulation of centric relation, protrusion, and laterotrusion movements. Two types of virtual articulator are available on the basis of method of simulation of jaw motion:

- Mathematically simulated articulator
- Completely adjustable articulators (motion analyzer).[7]

Both virtual articulators and digital facebows provides effective, efficient, and accessible digital companion during diagnosis and treatment planning.

LASER:

The laser is an acronym, which stands for "light amplification by stimulated emission of radiation."
Various hard and soft tissue lasers used in dentistry:

(i) Er: YAG laser- Hard tissue laser
(ii) The CO2 laser- Soft tissue laser
(iii) Argon laser
(iv) Nd: YAG
(v) Diode laser.[18]

The current trend is using commercially available small, portable, cordless, low-cost lasers, such as the NV1 (Discus/Philips) and iLase (Biolase)

Application of Lasers:

- In removable prosthodontics:

Lasers are used in vestibuloplasty, frenectomy, to contour irregular ridge, removal of interfering tori and hyperplastic soft tissue.

- In fixed prosthodontics**:**

Laser are used for crown lengthening, formation of ovate pontic sites, soft tissue management around abutments, tooth preparation for veneers and full coverage crowns and bridges, removal of the carious lesion and faulty restorations etc.

- In implantology:

Laser is used for second-stage uncovering and peri-implantitis.[18]

- In the maxillofacial prosthetics:

Laser are used for 3D acquisitions of optical data of the extraoral defects, thereby eliminating the need for conventional impression techniques its associated disadvantages such as discomfort to patients and deformation of the soft tissue.[18]

Dental Robots in prosthodontics

The use of dental robots, especially in prosthodontics, can be realistic future. The data input of experienced personnel is coded to robots which can aid in productive prosthodontic actions.[19]

In Removable Prosthodontics

In removable complete and partial dentures robots have been used for teeth arrangement. Examples are: CRS robots for complete denture tooth arrangement. [19]

Dental Implantology Robot

Applications of robots for the implant surgical procedure has been a research theme in many of the research and medical centres recently.[20]

The first commercially available robotic system for dental implantology is named **Yomi.** It was developed by Neocis Inc, USA and approved by FDA in 2017. Yomi is a computerized navigational system intended to provide assistance in both the planning (pre-operative) and the surgical (intra-operative) phases of dental implantation surgery.[20]

2. Conclusion

Although conventional techniques in dental care have worked excellently for decades, for a simpler, faster, more accurate and more efficient workflow application of current technologies is required.

Unless we are aware of the current trends and developments taking place in various fields relevant to the specialty, one will get isolated from the contemporary scientific arena with the risk of losing the perspective.

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