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DIGITALIZATION IN PROSTHODONTICS

Prosthodontics

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ABSTRACT

Digitalization has modified various aspects of conventional prosthodontics procedures. Digitalization has become part and parcel of the contemporary prosthodontics be it in the clinical or lab procedures. The use of CAD-CAM technology, virtual articulators and digital facebows, digital radiography has enabled the prosthodontist to perform various procedures with ease and greater perfection.

KEYWORDS

Virtual dentistry, CAD-CAM, Digital prosthodontics, Digital advances.

INTRODUCTION:

The field of dentistry continuously demonstrates innovation and improvement on many fronts. The more recent advances in dentistry have involved the adoption of digital technologies in all forms to improve the quality of care and patient experience. Digital dentistry includes the broad array of technologies that bring the communication, documentation, manufacture and delivery of dental therapy under the umbrella of computer based algorithms.

Broad dissemination of digital technologies in dentistry began with the development of the first intra-oral sensors in 1980's which paved way for the use of digital radiography in dentistry.[1] Digital technology is driving remarkable change in the practice of prosthodontics. It was in 1980's that advances in computerization, optics, miniaturization and laser technologies enabled capture of dental impressions.[2] Today with a variety of latest versions of intra-oral scanners and computer aided design and computer aided manufacturing (CAD-CAM) technology, same-day chair side restoration of remarkable dimensional and esthetic fidelity is possible.

Digitalization being so significant in dental practice needs to be understood well. The arrays of developments need to be known, as they either affect the contemporary practice or may have significant futuristic outcomes and hence gives an endless scope of revision. This will help the dental fraternity to be refreshed with the latest and inculcate these technologies in their daily practice.

1. RADIO-VISIO GRAPHY :

Digital radiography in dentistry was first introduced as RVG in 1987. Advocated by Dr Francis Mouyen in 1989, RVG system enables the operator to capture the radiographic images from the patient's mouth via an intra-oral sensor [fig 1]and transfer of this image to the computer.[3] [fig 2]

fig 1

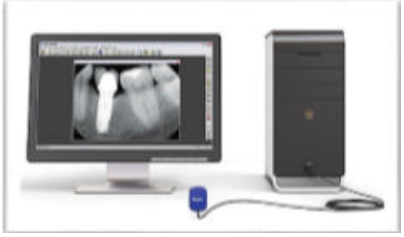

fig 2

The RVG system is able to produce radiographic images immediately after exposure and at a considerably lower dose levels than are necessary for films. The resolution provided by RVG is lower than that of the conventional periapical films. However, the images obtained by RVG can be modified , zoomed, rotated, cut or edited or manipulated by enhancement, contrast stretching and reversing.

Digital radiography offers immediate viewing of images which is highly desirable during implant procedures, vital tooth preparation, post placement and patient education.[4]

2. COMPUTER AIDED DESIGNING AND COMPUTER AIDED MANUFACTURING (CAD-CAM):

CAD-CAM technology systems use computer with integrated software linked to a milling device to collect information, design and manufacture a wide range of products. This technology was introduced to dental community in early 1980's by Mormann & Brandestini (1989).[5]

All CAD-CAM systems have 3 functional components[6]:

I. Data capture or scanning using optical cameras, contact digitization and laser scanning, to capture and record data about the oral environment (e.g. tooth preparation, adjacent teeth and occluding tooth geometry).[fig 3]

ii. CAD to design restoration to fit the preparation and to perform according to conventional dental requirements.[fig 4]

iii. CAM to fabricate the restoration.[fig 5]

This technology is not only used in the dental labs but with recent advancements it is also being used in the dental clinics in making chair-side restorations; from smaller restorations like inlays, onlays, veneers and crowns to larger restorations like FPD, CD, RPD, maxillofacial prosthesis, implant abutments and full mouth restorations.

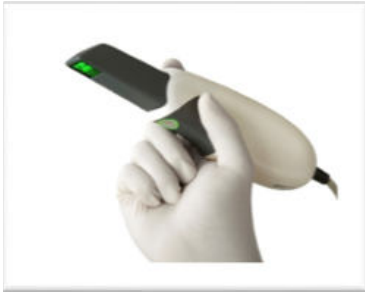

fig 3

fig 4

fig 5

3. CONE-BEAM COMPUTED TOMOGRAPHY (CBCT):

CBCT (also referred to as C-arm computed tomography, cone beam volume computed tomography, flat panel computed tomography) is a medical imaging technology of CT where X-rays are divergent, forming a cone.[8] [Fig 6] CBCT systems have been designed for imaging hard tissues of the maxillofacial region. CBCT is capable of providing sub millimeter resolution in images of high diagnostic quality, with short scanning time (10-70 sec) and radiation dose reportedly upto 50-100times lower than those of conventional CT scans.[9,10] CBCT produces a series of stacked sequential cross sectional images. Images are usually thin slices (e.g.1mm thick) of known

separation (e.g. 1mm apart).[9] Resultant images provide a 3D representation of the maxillofacial skeleton with minimal distortion and helps in virtual treatment planning, assessment of bone height and width for implant site assessment, the inferior alveolar canal in relation to impacted mandibular molars, condylar surface and shape in symptomatic Temporomandibular joint surgical assessment of pathology, seeking out impacted teeth, pre and post-operative assessment of craniofacial fractures.[8,9,10][Fig 7]

Integrating CBCT images with the CAD-CAM interface has led to the development of precision fabrication of surgical stents, thereby facilitating in proper implant placement.

For prosthodontists, CBCT is a very strong armamentarium for the comprehensive rehabilitation of patient by increasing access to 3D radiographic assessment in clinical practice.

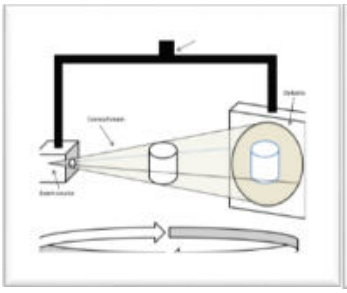

fig 6

fig 7

4. T-SCAN:

The T-Scan Occlusal Analysis System (Tekscan,Inc) was developed by Prof William L. Maness in partnership with MIT in 1987.[11] The latest type of this technology is marketed as T-scan III system, accompanied by a software version 8.0, Tekscan Inc.

Tek-scan III can be used as a diagnostic tool in the diagnosis and treatment of all occlusion related temporomandibular disorders providing occlusal equilibration at the end of treatment.

Tek-scan III consists of a sensor, handle, cable, system unit and software. [Fig 8 &9] The sensor is an ultra-thin (0.004", 0.1mm), flexible printed circuit that detects patients occlusal forces. The USB handle gathers the data from the sensor and processes it so that it can be easily sent to the computer. The handle-attached USB cable is then connected directly to the USB port. The system unit contains electronic sensor for viewing, analyzing and recording occlusal data. Initially, the monitor displays the tooth contact as they occur in real time. This display compares occlusal contact patterns.

This technology overcomes the limitations of using articulating paper in analysis of occlusion. Studies show that the use of articulating paper in analysis of occlusion is not accurate in determining the occlusal contact and duration of occlusal contact. During intercuspidisation, time and force are the main occlusal factors measured with the Tek-scan system.

The Tek-scan provides analysis of relative occlusal forces that are recorded using intraoral pressure sensor and displays the occlusal forces to minimize the possibility of repeating mistakes when occlusion is examined by articulating paper and it depends on the subjective feeling of the patient.[12]

fig 8

fig 9

5. VIRTUAL ARTICULATOR AND FACEBOW:

Virtual articulator provides a quantifiable, repeatable and reliable method of transferring the location of the maxillary dental arch from the patient (virtual facebow transfer) by means of reverse engineering devices to design a customized dental restoration.[13] This procedure allows the dentist and the dental laboratory technician to work in a fully digital environment without having to mount the casts on a mechanical articulator.[Fig 10 & 11]

The programming and adjustment methods of the virtual articulator were described by Kordas and Gartner in 1999.[14] The first virtual articulator developed by Szentpetery at the Martin- Luther university of Halle, Germany, was based on a mathematical simulation of the mandibular movements that take place in an articulator.[15] The second version was developed by Kordas et al and Gartner at Greifswald university, Germany. That articulator was designed to record the exact movement paths of the mandible by using an electronic jaw movement registration system called Jaw Motion Analyser (JMA) and then to move digitized dental arches along those paths in the computer. With these tools, static and kinematic occlusal collisions could be calculated and visualized.

The virtual articulator has been designed for exhaustive analysis of static and dynamic occlusion with the purpose of substituting mechanical articulators and avoiding their errors. Virtual facebow is an effective and accessible digital companion to dental implant diagnosis and treatment planning

fig 10

fig 11

6. JOINT VIBRATION ANALYSIS (JVA):

Temporomandibular Joint Vibration Analysis (JVA) is the electronic recording of TMJ sounds or more accurately vibrations occurring in the joint.[16] In healthy joint, synovial fluid permits smooth gliding motion without any vibrations which are caused in case of any degeneration, perforation or mechanical displacement. Over the past several years many objective and subjective methods have been developed to record and analyze the TMJ sounds. One such method is Joint Vibration Analysis.

JVA is a personal computer based tool which is based on the principles of motion and friction.[17] [Fig 12]It is a precise, quick, non invasive[17,18], passive device that objectively records all the vibrations of the underlying tissue during function[19], distinguishes which side the vibrations originate on, creates a virtual image of the vibration and measures its intensity.

The modern JVA records sound waves by a highly sensitive skin contact transducer called piezoelectric accelerometer (which generates surface electric charge when subjected to pressure or stretching).[Fig 13] The accelerometer is silicone based, therefore, extraneous sounds are dampened and only TMJ vibration are recorded.[18]

JVA helps the clinician to identify one vibration pattern from another and to distinguish primary dysfunction from other painful conditions.

fig 12

fig 13

CONCLUSION

Digital technology has immense influence over the clinical aspect, laboratory procedures, training of students, patient motivation, practice management and not the least dental research. Today a dentist in general and a prosthodontist in particular have ample of options to choose from but needs to be abreast with the developing technology to avail them all. With the mounting research it is quite challenging to keep pace with it but it is the need of the hour.

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