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Applications of Digital Fluoroscopy in Dental Practice – A Review

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Abstract: Digital fluoroscopy has unlimited potential in dentistry. It is an x-ray related medical imaging technique and provides dynamic or continuous moving images on a monitor which makes the dentist to work easier and faster. The amount of radiation in dental fluoroscopy is considered as minimal when compared to the conventional radiography and the risk for radiation exposure is very low. Functional examination of particular region of interest is done with the help of fluoroscope. In near future fluoroscopy usefulness can be increased by developing the technology, which allows dynamic radiographs for dental use.
Keywords: Fluoroscopy, Radiology, Dental imaging, Dynamic radiograph

Introduction

Dentistry always focuses on upgrading diagnostic procedures and treatment plan by using latest available technology[1]. Digital fluoroscopy is a kind of medical imaging which generates x-ray images and allows real time viewing of the patient with high temporal resolution[2]. It helps in viewing dynamic structures in detail, like movements of the body parts and surgical instruments during the procedure. They are often used to position the imaging system for the recording of images (e.g., angiography) and to provide imaging guidance for interventional procedures (e.g., angioplasty)[2]. Fluoroscopy was not routinely used in dentistry due to increased radiation exposure, device size and poor image resolution[3]. Modern fluoroscopic systems use image intensifiers (IIs) coupled to digital video systems or flat panel digital detectors as image receptors[2]. As a result of this there is dose reduction in patients upto 1/30 - 1/80 of the dose needed to expose a conventional dental radiograph[4]. The

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goal of this review is to determine the use of fluoroscopy in various fields of dentistry and its applications.

History

After discovery of x-rays by Roentgen, William Herbert Rollins worked on applications of X- rays in dentistry[5]. He invented dental fluoroscopy in 1896 which is similar to X- ray machine[5]. However fluoroscopy does not produce stagnant images, it provides constant visual feedback[6]. Advances in fluoroscopy include the application of image intensifying principle, which was introduced in 1942[3]. The first image intensification unit was invented in 1953 were the harmful effects of radiation is reduced[7]. An image intensifier with low mA level decreases the patient and operator dose[7].

Basic Physics And Principles Of Digital Fluoroscopy

Principle

The basic components required for the production of fluoroscopy images are x-ray generator, x-ray tube with filters, collimator and image intensifier which converts x-ray into an optical image[8]. The principle is to produce real-time x-ray images with high frame rates and a low-dose per image [2]. "Real-time" imaging is generally measured to be 30 frames per second (FPS), adequate to provide the appearance of continuous motion[2]. A 10-minute "on time" fluoroscopic procedure, if directed at 30 FPS,makes18,000 individual images which can be played back as a movie loop with subsequent filing in the patient's electronic record in the picture archiving and communications system (PACS)[2].

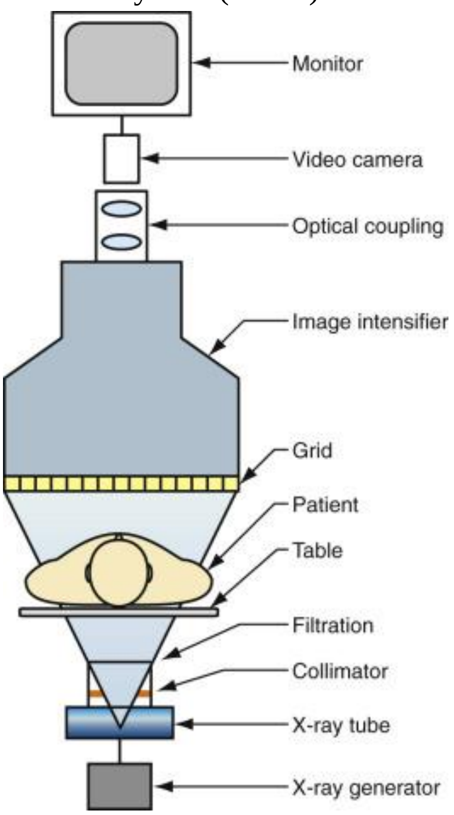

Fig 1: Shows Components of Fluoroscopy[9]

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IIs and fluoroscopic flat panel detectors are the two detectors which operate in a mode that is several thousand times more sensitive than a standard radiographic detector.[2]

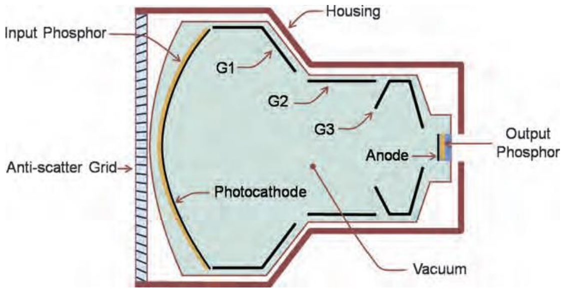

Fig 2: Components of Image intensifier system [2]

The main components of an II system are, 1).Vacuum housing which retains air out and permits unimpeded electron flow[2].
2). An input layer which is made of caesium iodide crystals of approximately 400 mm tall and 5mm in diameter. It converts the absorbed incident x-rays into light, which inturn stimulates the photocathode to emit electrons, which are ejected into the electronic lens system[2].
3). An electronic lens system comprising of the cathode, anode, and three additional focusing electrodes (g1, g2, and g3)[2]. These electrodes fasten and focus the electrons emitted by the input layer onto the output layer[2].
4). An output phosphor that converts the accelerated electrons into a visible light image [2].
5) A light-sensitive camera such as an analog vidicon or solid-state CCD or CMOS system is optically coupled to the output screen of the II[2]. This is used to pass the output image to a video monitor for visualization by the operator.[2]
Flat panel detectors are made of thin film transistor (TFT) arrays of individual detector elements (dexels) that are packaged in a square or rectangular area[2]. Indirect and direct x-ray conversion modes are employed in TFT panels for fluoroscopy applications[2]. In both the systems, each detector element has a capacitor, which collects and stores the signal as an electrical charge, and a transistor which serves as a switch[2].Flat panel receptors replace the II, optics, video cameras, digital spot film devices and cine cameras in a much lighter and smaller package.[2]
C- arm/ U- arm configuration produces 2 dimensional images while O- arm configuration produces 3 dimensional images[10]. Recently C-arm fluoroscopy x-ray system has x-ray tube housing assembly and image receptors which are arranged in a spatial relationship[10]. Such system allows changes in the direction of beam axis according to the patient's position so adjustments are not needed[10].

Applications of Fluoroscopy in Dentistry

Radiographic image plays an important role in diagnosis and treatment planning in dentistry[11]. Conventional radiography has limitations like distortion and magnification which leads to misrepresentation of structures[11]. Fluoroscopy produces live images of oral and maxillofacial region, for diagnosis and assessment of disease severity and for planning treatment[12]. Fluoroscopy is widely used diagnostic tool in several areas of dentistry such as radiology, prosthodontics, endodontics, orthodontics, maxillofacial surgery, pedodontics and forensic dentistry[6].

In Prosthodontics fluoroscopy can be used to design prosthesis for cleft palate patients[13]. Visualization of complete denture base movements during mastication and phonetics[13]. For assessing anatomical structures, landmarks and problems in articulation of tongue during speech[14]. For the evaluation and diagnosis of dysphagia[15]

In implantology microfocus x-ray fluoroscope provides a clear and distinguishable image of bone implant interface due to their high spatial resolution[16].

In oral surgery fluoroscopy is used to remove salivary duct stones by visualizing them through the duct and for presurgical evaluation of impacted molars[17]. Identification of tooth angulation, root morphology and approximation to inferior alveolar nerve canal[18]. It has been used for locating foreign bodies in maxillofacial region[19]. Removal of broken instrument tips, needles, part of dental implants, endodontic files and reamers[20]. For location of anatomic proximity in critical structures and aesthetic consideration areas which has become a great challenge for surgeon for retrieval of foreign bodies[21].

In oncology fluoroscopy plays an important role in diagnosis[22]. CT fluoroscopy guided biopsy is a minimally invasive imaging technique that enables real time assessment[22]. This technique can be used for taking biopsies of oral cancer[22]. To assess the oropharynx region and to check patients swallowing after glossectomy, videofluoroscopy is useful[23].

In orthodontics fluoroscopy can be useful in functional evaluation of malocclusion and assessing mandibular advancement in sleep related disorders[24]. Also used for diagnosing condylar position during mandibular movements[24].

Application in TMJ disorders – Fluoroscopy is useful for the management of temporomandibular joint disorders like hypermobility, jerk movements, ankylosis, degeneration of the joint space, mechanical cause of joint limitations[25] and also used for measuring 3-dimensional mandibular kinematics[26]

In forensic radiology fluoroscopy is used to determine the cause of death, locating hidden foreign objects and to evaluate anatomic areas that are difficult to dissect[27]

Safety in Fluoroscopy

Safety of fluoroscopy has been demonstrated in many studies[28]. By measuring its radiation dosage and comparing with dental radiographs, the radiation exposure is one hundred times lower than the average intraoral radiograph[28]. As a result of this the risk of radiation exposure to radiosensitive organs is reduced[29]. Modern units emit x-rays as short pulses instead of delivering continuously, thus lowering the exposure to patients and operators[29] Recently fluoroscopy shows increase in exposure time without increase in the dose equivalent of radiation due to its low mA setting and use of image intensification in contrast to digital dental imaging and intraoral radiography[30]. X-rays produced in fluoroscopy are controlled independently[31]. Image receptors in fluoroscopy has undergone a revolutionary transformation recently from larger analog device to digital device[31].

Advantages of Fluoroscopy

- Allows real time interaction with the patients[32].
- Reduced exposure to the patients and good image quality[33].

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- Allows dentists to see a live image in order to observe their size, shape, position and movements[33].
- Good for visualizing bone structures[33]
- Provides dynamic information[33].
- Decreased exposure to patients when compared to conventional dental radiograph.[33]

Limitations of Fluoroscopy

- Poor soft tissue resolution[33].
- Some fluoroscopy procedures are longer and also due to use of ionizing radiation may cause injury to the skin and underlying tissues[33].
- Difficult to perform in children and patients with motor deficits associated with swallowing disorders. [34]
- Contrast dye, if used may produce allergic reactions in some patients[34]

Conclusion

Fluoroscopy is a relatively inexpensive technique but less appreciated in diagnostic radiology. It should remain as an essential modality in the age of high resolution CT, MRI and ultrasound. Fluoroscopy minimises the radiation dosage to patients and operators, prevents the procedural accidents and saves working time for the dentist.

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