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Review

Intraoral Imaging Techniques and the advantages of Ultrasound in the Dental Field

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Abstract

Over the course of time, a multitude of intraoral technologies have been invented, modernized, and improved in order to create the advanced modern technology that is used in dental practices today. Since the time of the earliest dentist in the 1830's, there have been tremendous global improvements in the intricate details of dental equipment. The advancement of technology from photography to radiography to ultrasounds has developed dentistry into a prominent, impactful industry.[1] Ultrasounds have proven to be a unique area of dentistry with the potential to transform the future of the dental industry. Technological advancements regarding X-rays have had a high rate of growth in the last decade and have only continued to improve with the new technology of ultrasounds within the field of dentistry.

Introduction

The technological era began in the eighteenth century. This time period was a revolution as the development of machines were invented and the way life was lived began to shift. This time period coincided with modern dentistry as it too began in the eighteenth century. Pierre Fauchard was the first dentist to record modern practices of dentistry in his book "The Surgeon Dentist, A Treatise on Teeth." Although the technologies used back then were not the same as common practices today, it was the foundation in developing knowledge on what future dentists would eventually use to improve dental medicine.

First Intraoral Photograph

In 1839, the Paris Academy of Sciences introduced the process of photography, and thus, the first intraoral photograph was taken. Later that year, Alexander S. Wolcott paired with John Johnson and created a small business that produced optical and medical instruments. In 1840, Wolcott and Johnson designed and patented the first camera-based model known as the 'mirror camera.'As the creation of the camera was fascinating, many dentists started searching

for photographic devices to obtain intraoral images. However, there was one major issue that presented itself: there was no clear way to get light from the camera's flash within the dark crevices of the mouth. Despite using many types of close-up focused lenses, the images taken were unclear. The challenges that were encountered in early intraoral photography opened up pathways and research to discover more advanced techniques for oral photography.[2]

Discovery of X-rays

After over three decades of dental research and unsuccessful inventions, in 1895, German engineer, Wilhelm Röntgen, discovered X-rays. This was a scientific breakthrough as the world had never before seen the inside of an animal or human before. Later that year, Dr. Otto Walkoff, a German dentist, invented the first dental radiograph. The radiograph, produced by X-rays, took twenty-five minutes of exposure while having the patient lay on the floor with specified glass receptors within their mouth. The following year, Dr. C. Edminds Kells from New Orleans was the first to actively use an X-ray on dental patients. Thus, he is given the title of 'the father of dental radiography.' This new invention had an enormous influence on the world of dentistry which opened many doors for research.[3] At the age of eighteen, Dr. Frank Van-Woert invested his time in research in oral and maxillofacial radiology. He established a practical demonstration of dental radiography and presented it before the New York Odontological Society. Dr. Van-Woert discovered the first dental X-ray film, which used less radiation. This technology was groundbreaking and implemented into practices for the next one hundred years.

Advancement in X-ray Imaging

In 1987, Dr. Francis Mouyen advanced X-ray imaging by decreasing the X-ray image size. He introduced the new technology of digital imaging to the dental world by inventing a way to employ fiber optics in order to create a smaller-sized X-ray. The mechanism he used was a device called the CCD, the charge coupled device, which operates as an image sensor chip. This sensor enhanced the visualization of unseen areas that other X-rays did not have the ability to photograph. This would impact dentistry as the X-ray imaging was safer, since it emitted less radiation, and the new capabilities of fitting into a person's mouth which would make it easier to identify hard to reach crevices. Later that year, Fuji

Optical Systems of California produced the first intraoral camera. This resembled what current video cameras are like today. Due to the hard work of dentists and researchers, the advancement of dentistry globally has impacted radiography, X-ray technology, and intraoral photography.[4]

With Dr. Mouyen's technological advancement of the new X-ray, there were a multitude of processes that took place. The multi-step process required a dark room due to the chemicals that were present during the process and in order to decrease the exposure from film light. After the X-rays were placed in a dark room, they were laid on a light box in order to ensure better visualization of the X-rays. Past technologies included many harmful chemicals, time-consuming processes, wasted space, and low quality images. The process took up much space within the patient's files and was a waste of time and materials, concluding the time-consuming process with an unclear appearance of an X-ray. In order to improve these faculties, new technology such as digital X-rays have come about in recent years (Figure 1). These technologically advanced products include 3-D technology, which enhanced the imagery on the tooth anatomy, clearly revealing bone decay, bone infections, gum diseases, abscesses, and any development of abnormalities.

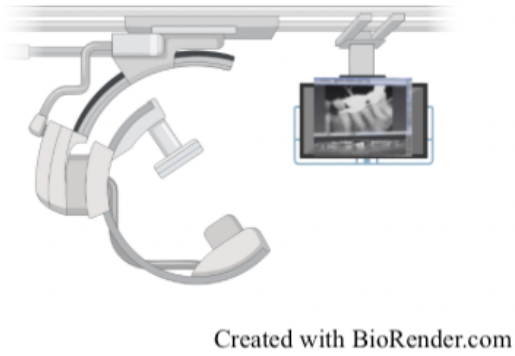

Figure 1: Advanced Intraoral X-ray

Benefits of Radiography

After this advancement, radiographs became the most common way to discover disease in a patient. Conventional radiographs work similarly to cameras. In order for a radiograph to transform a three-dimensional object into a two-dimensional image, the X-rays form a beam directed at the sample being tested. The pattern that is absorbed by the sample is projected on an analog film or a digital receptor and thus used for further studies.

Radiographic imaging provides high-quality images while also having the ability to capture images of unobstructed areas in the body that may otherwise not be visible due to the tissue and muscles that lay above it. Additionally, this type of imaging allows for

a snapshot of bone, skull, and many other hard structures.

When it comes to root canal therapy, radiographs play a key role in diagnosis, treatment, and follow-up. Given that an X-ray is the most accurate objective method, diagnosing a patient for diseases affecting the maxilla and mandible was a common practice in endodontics.

Negatives of Radiography

There are several downsides to radiographic imaging. Firstly, in terms of root canal therapy, the X-rays do not accurately depict the size of the lesion or how it fits in relationship to the surrounding teeth and crevices in the mouth. Secondly, in order to capture these radiographic images, the patient needs to be exposed to small quantities of radiation. Both of these pitfalls can harm the patient as it can cause indirect pain and long term negative effects towards them.[5]

Combining the modalities of both intraoral scanning and radiographic imaging can allow for a safer, more efficient way to successfully prepare for surgical restorative dentistry cases. In dentistry, intraoral scanning provides dentists with high-quality images of the patient's oral environment, specifically tooth structures.

Ultrasonography Technology

While radiographic imaging and intraoral scanning work efficiently enough to get the job done, scientists are always looking for ways to improve their methods in order to make a patient's visit more pleasant and less painful. "Majlesi was looking to solve this issue, to do so he compared and conducted a study on 72 patients with pain in upper trapezius muscle." The main objective of this study was to resolve spasms and reduce pain. The test resulted in an increase in blood flow within the tissue causing the initial pain. After the test results were conclusive they discovered how to relieve the pain by using a combination therapy followed by tens therapy to relieve the muscles spasms. [6]

Currently, researchers are attempting to implement the use of diagnostic ultrasound in dentistry. Diagnostic ultrasound is a non-invasive technique that is used to take images inside the body. Anatomical ultrasounds produce images of the body's internal organs and functional ultrasounds compile information of physical

characteristics such as the movement of blood or softness of tissue.[7]

Ultrasounds were designed by using technologies that conduct sound waves inside the body and receive information from the waves that echo back. Ultrasound probes, also known as transducers, emit sound waves that have frequencies above the threshold of human hearing. Usually, ultrasound probes are placed on the skin, in order to enhance the image quality. Although it is also common for these probes to be placed inside the body via the gastrointestinal tract, vagina, or blood vessels during urological procedures.[8]

Functional ultrasounds combined with anatomical ultrasounds produce "information maps." Information maps help doctors visualize the patient's organs externally without having to operate and see the problem internally.

An additional benefit in using ultrasounds with patients is that there is no exposure to radiation. For patients that need to be monitored frequently, constant exposure to radiation, even at small amounts, can be dangerous, making ultrasound a good alternative.

Ultrasonography in Different Specialities of Dentistry

Studies have shown the positive effects of using Ultrasounds in multiple areas of dentistry. Although this technology is fairly new, it is forecast to be implemented in many offices over the next few years (Figure 2).

"Ultrasound was capable of detecting auto-immune diseases, mucosal growths and had a high rate of detecting oral cancer lesions."

With studying Ultrasonography in oral medicine, it was found that Ultrasound was capable of detecting auto-immune diseases, mucosal growths and had a high rate of detecting oral cancer lesions. Additionally, there was a specific focus on Sjoren's syndrome, which is an auot-immune disease that is identified by dry eyes and dry mouth, and it showed positive results when tested.

In orthodontics, Ultrasonography was found beneficial in reducing the size of root resorption due to the multiple orthodontic forces that were done to that area. Also,

when ultrasonography was used, it reduced the patient's treatment time.

When ultrasonography was compared to MRI, and magnetic resonance imaging, it was found that Ultrasonography is more resourceful as it gets results faster and more accurately. This was true specifically for the study of diagnosing temporomandibular joints in patients.[9]

Therapeutic Ultrasounds

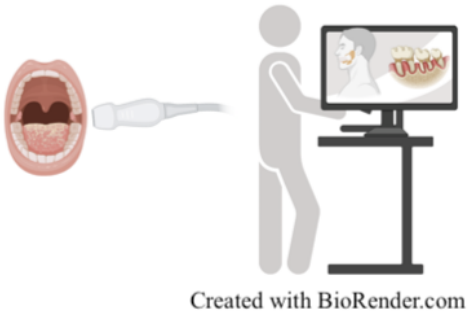

Figure 2: Intraoral Ultrasound

Additionally, another advantage to Ultrasonography is it can be used in a therapeutic manner (Figure 2). This is resourceful for dentists as many times they encounter patients with discomfort in the facial region as well as patients with facial syndromes such as Oral Submucous Fibrosis and Myofascial pain.

Oral Submucous Fibrosis is a disease in which the oral cavity is inflamed and the submucosal tissues have progressive fibrosis. When there is a severe case, this results in difficulty in movement and opening of one's mouth. In 2018, Vyoma Bharat Dani et al conducted a study with patients with this disease, his results were that movement improved with Ultrasonography and exercises compared to exercises alone.

Myofascial Pain is a chronic muscular pain disorder that is triggered by a stimulus like muscle tightness. This can result in TMJs and TMDs which dentists come across frequently. Grieder et al conducted a study in patients with TMD and Ultrasonography resulted in accelerated improvement when added to the normal muscle exercises.[10]

MRI Technology

In addition to Ultrasonography, MRI in dentistry leads a future towards radiation free imaging. Magnetic Resonance Imaging has been used to diagnose intraoral clinical problems. The application has been proven successful and aims to improve the efficacy of diagnosis and treatments. These treatments include mapping implants, jaw lesions, diseases such as TMJ, orthodontic

treatments, and endodontic treatments. The non-ionizing radio frequency electromagnetic radiation in the presence of controlled magnetic resonance imaging is a non-invasive technique that can detect abnormalities and diagnose elements in the soft tissue. The vital technology can help Doctors and Dentists alike to improve their diagnostic accuracy. [11]

Conclusion

Ultrasonography is the new and improved technology in the field that has created many opportunities for more advancements in treatments. It is efficient in intraoral photography that will better advance the accuracy as well as the efficiency of an oral X-ray. Over the years, the new technological advancements have enhanced the imagery of soft tissue visualization as well as clarified the images within the mouth, specifically gum tissue. Ultrasound technology has created a catalytic change in intraoral photography.[12]

As technology continues to progress, ultrasound machinery is only the beginning of the new developments that will collectively revolutionize and improve global healthcare industries. The forward technology is an-impressive process that uses a simplistic tool that has the capabilities that encapsulate the intraoral cavities and measure the gum tissue. This establishes an advanced, more efficient procedure. Today's advanced research comes to prove how the field of dental mechanisms has catalyzed. The way in which procedures are conducted are consistently improving and updating in order to limit pain, recovery, and treatment time. The broadened spectrum of forwarding thought will impact radiation-free imagery, as it continues to improve the future of medical technology.

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