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REVIEW ARTICLE

"FUTURISTIC ADVANCES THAT MIGHT CHANGE THE FUTURE OF ORAL MEDICINE AND RADIOLOGY"

Dr. Jaishri Pagare, Dr. Ankita Jain and Dr. Rashida Akolawala

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Abstract

Upgrading existing knowledge has been a part of human learning including new skills, technologies, and concepts. These technological advances make learning less user-dependent and increase inter-examiner reliability. The increasing scope of the specialty in the diagnosis of varied lesions, their early diagnosis, and their respective management. Radiological advances have eased the assessment of bone levels, soft tissue, metabolic and elasticity assessment, etc. In this review, we are going to discuss some of the latest technological advances for the diagnosis and imaging of oro-maxillofacial structures.

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Introduction:-

The importance of accurate diagnosis in treatment planning and management cannot be compromised. Though correct diagnosis is the mainstay of the most preferable and tailored treatment plan, the subjectiveness of diagnosis and treatment approach needs to be modified and standardized.

Medicine is the science of uncertainty and the art of probability. Though no approach can be idealized for conditions needing a medicinal approach, the clinician needs to be thorough with the latest advances and medicinal recommendations to catch up in this fast-moving world. After all,medicine is only for those who cannot imagine doing anything else.

Diagnosis is not the end, but the beginning of practice. The current diagnostic approach to all conditions is through clinical examination coupled with relevant radiographic imaging. Though sufficient to yield diagnostic information and reach at a diagnosis, this approach is immensely a subjective affair. The need of the hour is to behold conventional approaches but move to more reliable and newer diagnostic approaches which won't only standardize the procedure but also increase the diagnostic reliability of oral physicians. There is a dire need to inculcate the newer advances or procedures in day-to-day life apart from the fact that they help add value to our diagnosis.

Radiology blesses the diagnostician with a third eye to help with the reasonably unsolved. Radiology can be used for soft tissue examination as well with the newer advances which use lesser radiation doses, digital approaches, better technologies, and software interfaces. It has been the mainstay for diagnosing and treatment planning and has not been replaced till date since it was first commercialized dental radiographic machines by Victor X-ray company in 1923.

There are numerous new technologies that have been available commercially or are under review and studies still need to be carried out to determine the reliability of the procedures. Using the best possible technological advances to make work easier while sticking to the roots and accepting changes with an open mind. The advances might not

Corresponding Author:- Dr. Ankita Jain

always be new but have some input to add to the existing literature database. Some techniques which have been bringing revolutionary approaches with advances in knowledge and understanding include:

Oral Medicine and Diagnosis [1]

1. Nanomedicine
2. Nanotechnology
3. E-nose
4. Chemoluminescent illumination
5. Photodiagnosis (Optical spectroscopy)
6. Nanodiagnostics
7. Radionuclides
8. Sialoendoscopy
9. Oral CDX
10. Oral fluid testing
11. Intraoral Camera
12. VistaCam
13. Intraoral Scanner
14. LASER Treatment

Oral Radiology

1. PET Scan
2. Fusion Imaging
3. Volume Analysis
4. Optical Coherence Tomography
5. Ultrasound-guided Elastography
6. Artificial Intelligence
7. CBCT Sialography
8. 3-D Reconstruction
9. 3-D printing

There are other diagnostic and imaging modalities as well, such as advances in CT scan, MRI, etc., but have been used in common practice and are already gaining popularity. The once discussed in this review are newer advances which are away from the limelight but have great potential if included in routine dentistry.

Nanomedicine

Nanomedicine is the medical application of nanotechnology. Nanomedicine refers to highly specific medical intervention at the molecular level for treatment and repairing damaged tissues by injecting nanoparticles into the body. More precise and targeted treatment therapy with drug delivery at the cellular level might also reduce systemic side effects and dosages. Such therapy can be a boon in the field of Oral Medicine when these nanoparticles formulated as drugs will be made available to treat oral lesions and conditions.[2]Nano-triamcinolone gel has already been proven more effective than conventional triamcinolone gel for treatment of oral lichen planus in a study performed by RastinSadeghian.[3] So, this could be a revolutionary approach in line of treatment.

Nanotechnology

Nanotechnology has been applied in vaccine production which promotes innate immunity by simulating virus-like proteins. Since oral cancer is the third most common malignancy worldwide, its vaccine might bring an enormous change. Identifying the disease at an initial stage or even coupled with preventive measures like vaccination looks like a minimal disease approach to the future most individuals dreamt of.[4]

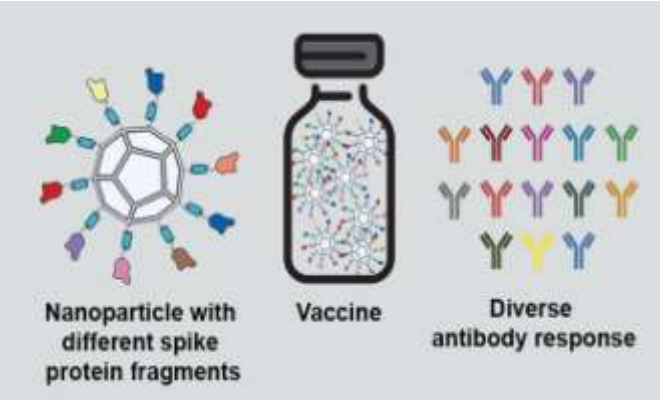

Fig 1:- Nanoparticle formulated vaccine.

E-NOSE

The e-nose is designed to and can assess the volatile organic compounds (VOCs) detected in the breath and derived from the cellular metabolism, which can be analyzed to identify the individual chemical elements as well as their pattern of expression to reproduce a sensorial combination similar to a fingerprint (breathprint). Gas mixtures are pumped towards the e-nose and, through a sampling device, are filtered to be then exposed to several sensors which produce signals which are processed through computerized algorithms based on pattern recognition and multivariate analysis. Diagnostic accuracy of 81% was observed, with 88% sensitivity and 71% specificity. E-nose is an efficient tool for OSCC detection in a limited resource setting, where it offers a valuable cost-effective strategy to tackle the burden posed by OSCC.[5]**A nose that can see is worth two that can sniff.**

Fig 2:- Electronic Nose.

Chemiluminescent Illumination

Chemiluminescence means light emission from a chemical reaction. Blue-white chemiluminescent light is shone into the mouth and tissue reflectance is observed. Dysplastic tissue appears aceto-white. Commercially available devices are Vizilite, Microlux DL units, etc. The accuracy of the system in diagnosing pre-cancerous and cancerous conditions is 80.6% compared to vital staining which offers an accuracy of 64.5%.Chemiluminiscent illumination did not change the provisional diagnosis, nor alter the biopsy site. It does not discriminate between keratotic, inflammatory, malignant, or potentially malignant oral mucosal white lesions [6]

Fig 3:-Chemoluminiscent illumination of suspicious tongue lesion

Photodiagnosis

Optical spectroscopy provides a quick diagnosis and relies on the fact that the optical spectrum derived from any tissue will contain the histological and biochemical makeup of the tissue. It is used for the detection of dysplasia, in performing guided surgeries, hemoglobin tissue perforation in a free flap, surgical margin assessment, and sentinel node biopsies. It is based on the principle of fluorescence and elastic scattering or a combination.[7]

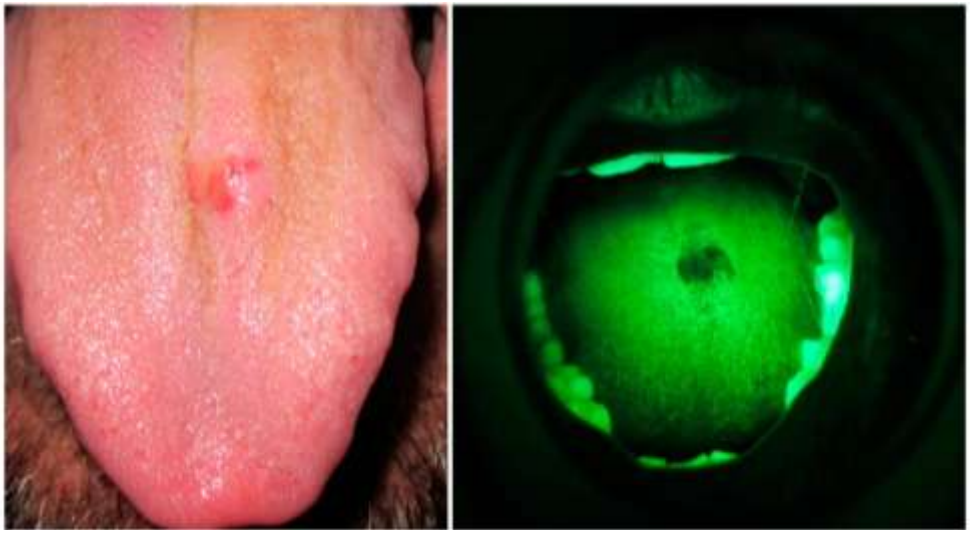

Fig 4:- Optical spectroscopy of suspicious lesion on tongue.

Nanodiagnostics

It is the use of nanotechnology for clinical diagnostic purposes. Developed for early detection and increased sensitivity, nanodiagnostic tools like gold and magnetic nanoparticles, quantum dots, etc. serve as bio barcoding tools as well, which is considered to be the future of PCR. The potential diagnostic applications include tumour detection, detection of the infectious agent, IHC (Immunohistochemistry), tissue imaging, fluoroimmunoassays, etc. Raman spectroscopy is the most promising imaging technique for gold nanoparticle-based contrast agents.[8]

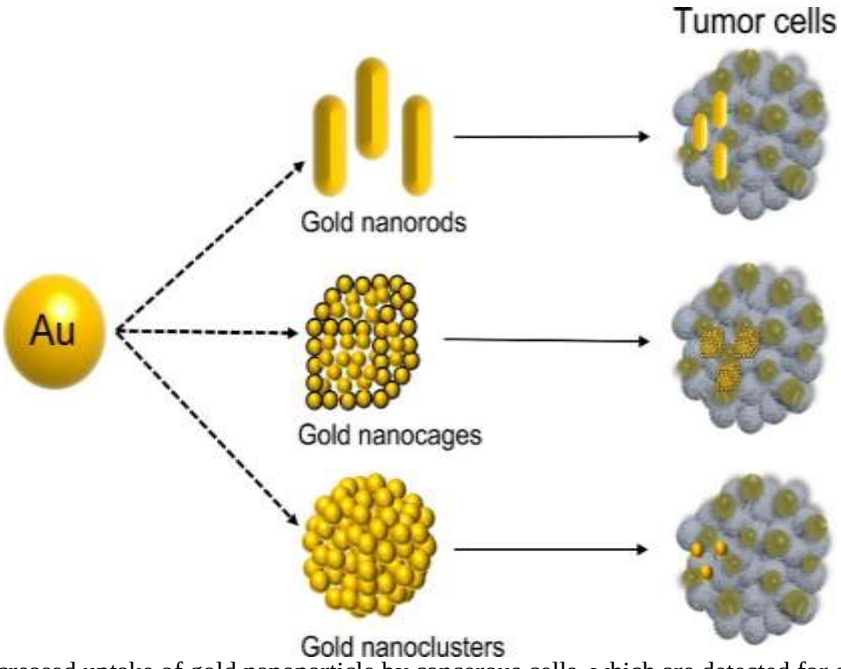

Fig 5:- Increased uptake of gold nanoparticle by cancerous cells, which are detected for diagnosis.

Radionuclides

Radionuclides, like technetium 99m-tin-diphosphonate, have recently been used as an indicator for active bone loss in periodontal disease activity, as active osteoclasts take up more radionuclides than adjacent normal bone or one which is in the resting phase of disease progression.[1] In the era of diagnostic radiology, progress lies not in enhancing what is, but in advancing towards what will be.

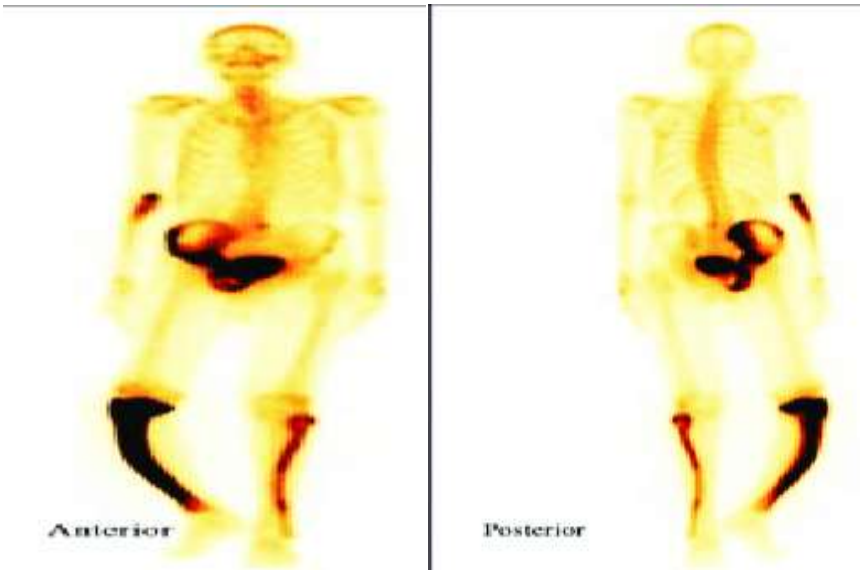

Fig 6:- Increased uptake of radionuclides as an indicator of active bone loss.

Sialoendoscopy

Intraductal and intraglandular pathologies can be observed by inserting 1-mm diameter endoscopes through dilated major salivary gland duct. Using mini-forceps, graspers, and balloon catheters, duct calculi can also be removed during the procedure. It can thus be used for diagnosis, treatment, and postoperative management of patients with salivary gland diseases.[9]

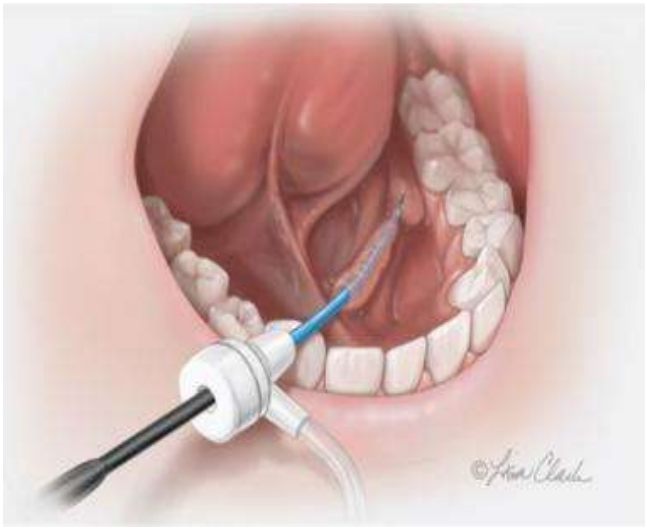

Fig 7:- Endoscopic evaluation of submandibular gland.

Oral CDX

Highly specialized and computer-assisted brush biopsy can be performed in the dental set-up for detection of suspected precancerous lesions or other lesions with a high turnover rate where superficial epithelial cells are readily available for screening, as in, pemphigus, candidiasis, etc. It helps in shortlisting lesions requiring biopsy, thereby saving the patient from undergoing any unnecessary surgical procedure. The procedure has been performed conventionally for long periods, but computer assistance after scanning intraoral mucosa helps increase specificity and sensitivity by identifying vulnerable sites.

Fig 8:- Computer guided brush biopsy.

Oral Fluid Testing

Salivary composition gives an insight into tissue fluid levels. So, testing saliva for systemic health can be an upcoming yet unexplored advancement. Exposure to environmental toxins and drug usage could be determined using microfluidics, microsensors, etc. The most recent example of this approach has been home testing kits for the detection of COVID-19. Circulating tumour markers might aid in early carcinoma detection.

Intraoral Camera

The intraoral camera helps in detecting hidden and overlooked areas of the oral cavity especially in cases with reduced mouth opening where an examination is not feasible or in difficult to access areas like the posterior one-third of the tongue which is more prone to cancer yet cannot be assessed accurately. It also aids in capturing high-quality intraoral images, thus improving diagnostic efficiency and achieving early referral.[10] Also, clearer images improve inter-examiner reliability. A camera is the save button for the mind's eye.

Fig 9: Intraoral Camera

VistaCam

This new intraoral LED camera is fitted with a light-induced fluorescence evaluator. "Cario" mode of this device provides different colours for healthy, infected and affected active, and arrested dentin. It also provides a magnified view of the tooth and helps in the early diagnosis of pit and fissure lesions compared to other fluorescence-based methods like Diagnodent.[11]

Fig 10: VistaCam

Intraoral Scanner

As has been realized that a number of TMJ issues can be treated with conventional approaches or with splints, the use of intra-oral scanners has to increase. Fabricating a splint on optical impression recorded with an intraoral scanner is more accurate and provides better results compared to a splint fabricated by conventional means. It also saves time and effort in making an impression.[12]**Be a possibility scanner.**

Fig 11: Intraoral Scanner

Laser Treatment

Various intra-oral lesions like lichen planus, leukoplakia, and mucositis have been successfully treated by low-level lasers. Also, conditions like gingival depigmentation, fordyce's granules excision increases the esthetics along with quicker healing and lesser post-op pain and inflammation.

Fig 12: LASER recontouring of gingiva

Pet Scan

Positron imaging tomography helps reveal metabolic or biochemical functions of tissues and organs. Radioactive glucose is induced to show both normal and abnormal metabolic activity. Not a replacement for clinical TNM staging of oral carcinomas, but as an adjuvant to the involvement of distant lymph nodes, and/or organs PET scan is an emerging modality, superior to CT and MRI. CT and MRI are more reliable for diagnostic purposes but PET scan is better for staging.[13]

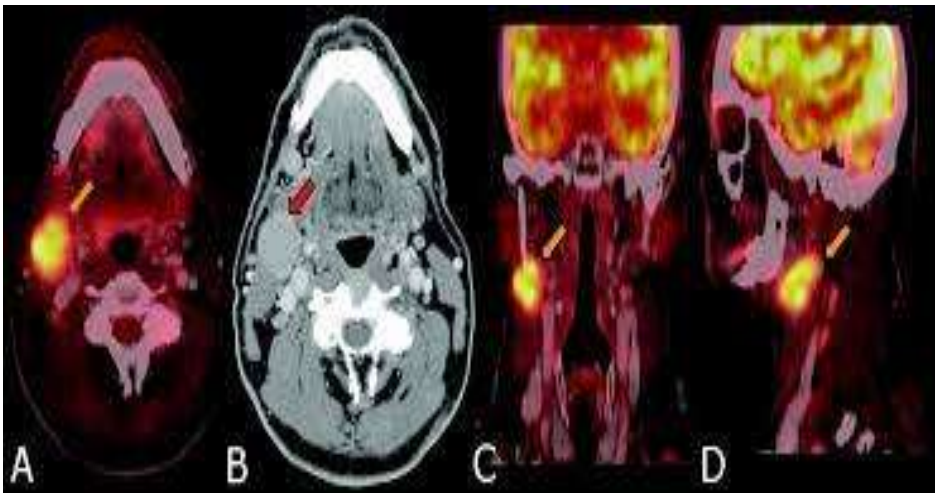

Fig 13: FDG PET showing areas of increased metabolic activity but poor anatomical correlation

Fusion Imaging

A technique that uses data from 2 imaging modalities, such as USG, CT, MRI, PET, etc. to improve the quality of diagnostic accuracy. PET fused with CT or MRI gives more accurate information by combining the functional data set from PET with the anatomical one, and also eliminates false positive and false negative findings on either of them. Great for early diagnosis and seeing the spread of diseases.[14]

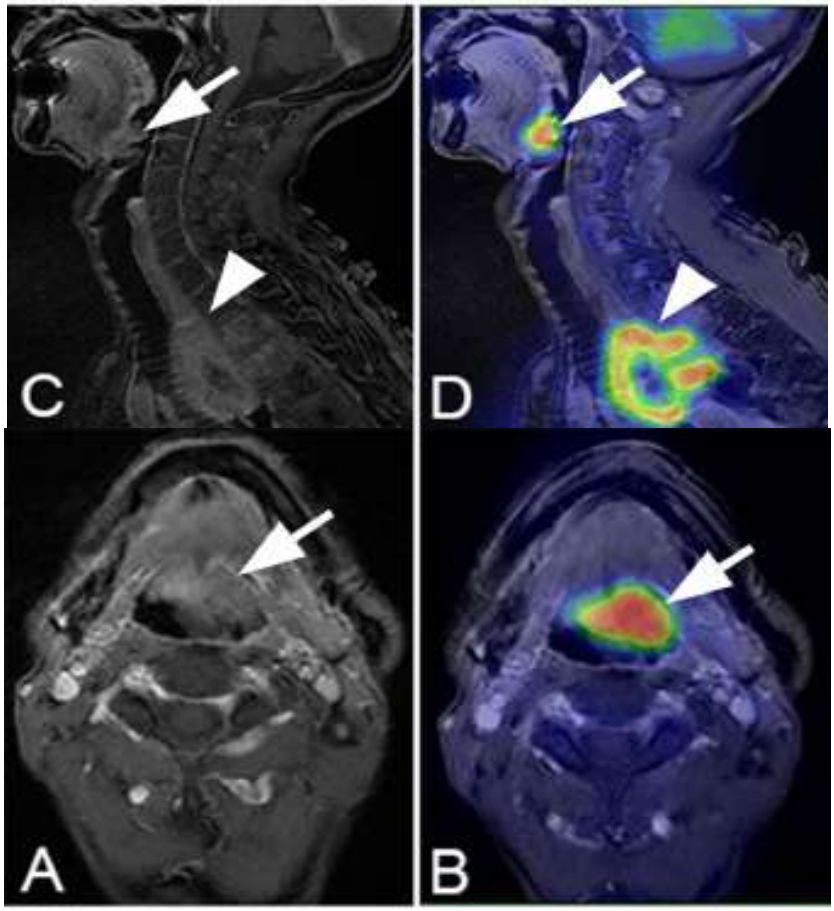

Fig 14.A,B: CT showing increased tissue mass

Fig 14.B,D: FDG PET overlapped over CT showing areas of increased metabolic activity

Volume Analysis

Using software incorporated with CT/CBCTthe volume of any organ, tissue or lesion can be calculated on a segmented DICOM image, which is useful in the analysis of lesion extent, pharyngeal volume calculation, etc. Pharyngeal volume is an important parameter as it is indirectly associated with lung capacity and the overall health of an individual. Tooth volume can be assessed for age. Third-party softwares like ITK-Snap, PostDICOM etc. also provide results in reliable range.

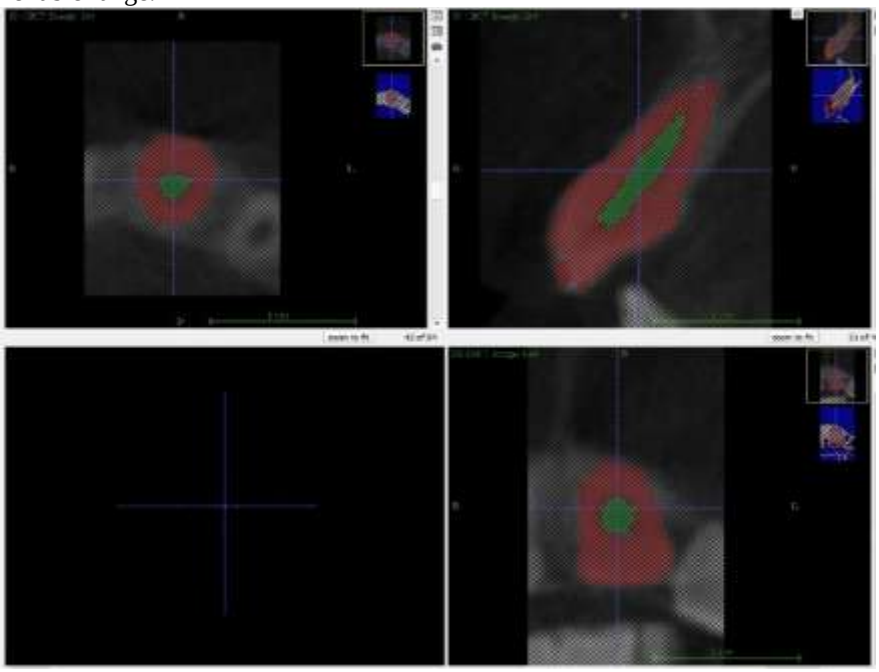

Fig 15: Markings for volumetric assessment in all 3 sections

Optical Coherence Tomography

OCT is an optical imaging technique that enables cross-sectional imaging of microstructures of tissue in situ. It can provide "optical biopsy" without the need for excision and processing. Images provide not only structure images but also optical characteristics like blood flow velocity and tissue orientation. It can be used to analyze the pulp-dentin complex, for early detection of tooth decay, periodontal diseases, and oral cancer.[15]

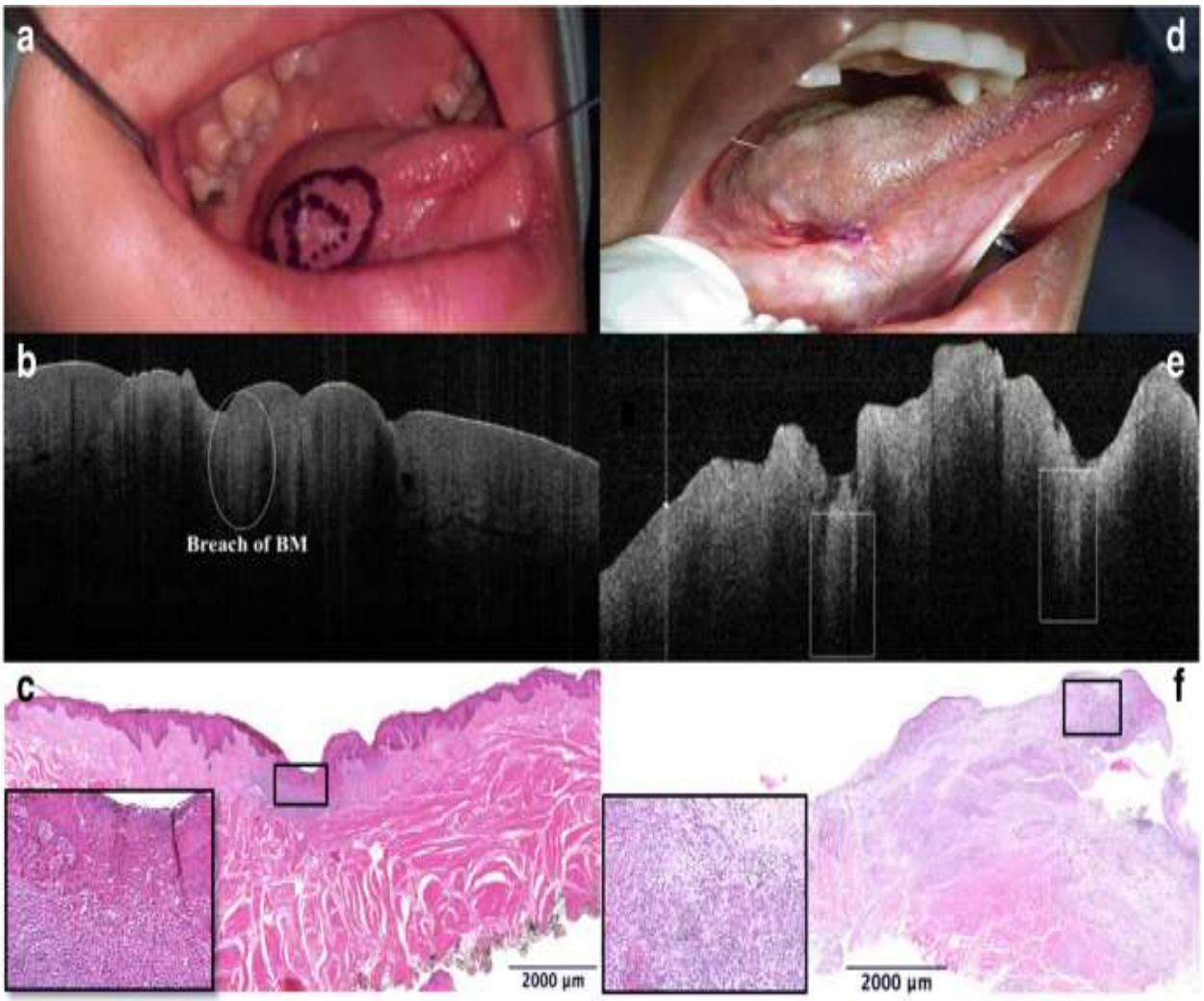

Fig 16.A: Suspicious lesion on lateral border of the tongue
Fig 16.B Scanned image showing breach in mucous membrane
Fig 16.C: Histopathology showing increased N:C ratio

Ultrasound-Guided Elastography

Elastography is medical imaging that maps the elastic properties and stiffness of soft tissues. It is basically a mechanical simulation of palpation. Used for decades for liver fibrosis, elastography is still in the initial phase for use in oro-maxillofacial conditions, but the work is promising and baseline values have been established for further studies. Most diseases alter tissue microstructure and hence its elasticity which can be used as an objective method of diagnosis.[16] Some conditions where ultrasound elastography can be of utmost importance are OSMF, SCC, TMDs, Salivary gland conditions, Cleft Lip, Lymphadenopathy, etc.

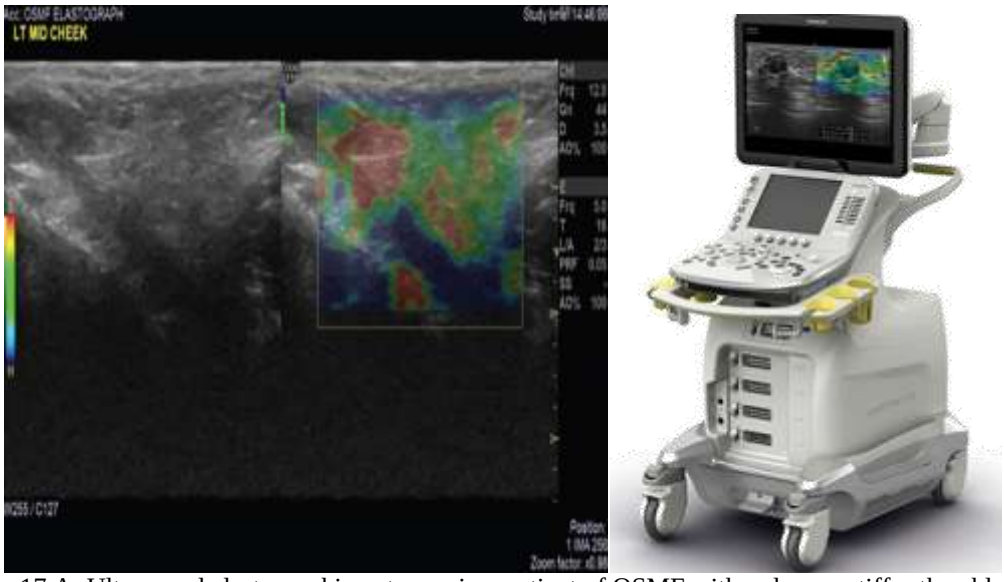

Fig 17.A: Ultrasound elastographic outcome in a patient of OSMF with red areas stiffer than blue
Fig 17.B: Ultrasound Elastography machine

Artificial Intelligence

Artificial Intelligence has taken over almost all aspects of our lives, though dentistry remains one of the "hard to replace" occupations. Still, with the help of convoluted neural networks, there have been certain start-ups working to incorporate AI in Oral radiology to improve efficiency. Clinical expertise combined with machine learning and AI technologies can create diagnostic reports, treatment plan suggestions, and predictions.[17] Further ORCA, dentalXr, Transabel, etc. have been into annotations of 2-D and 3-D radiographs which aids the radiologist in not missing out on stuff that they might feel is obvious.

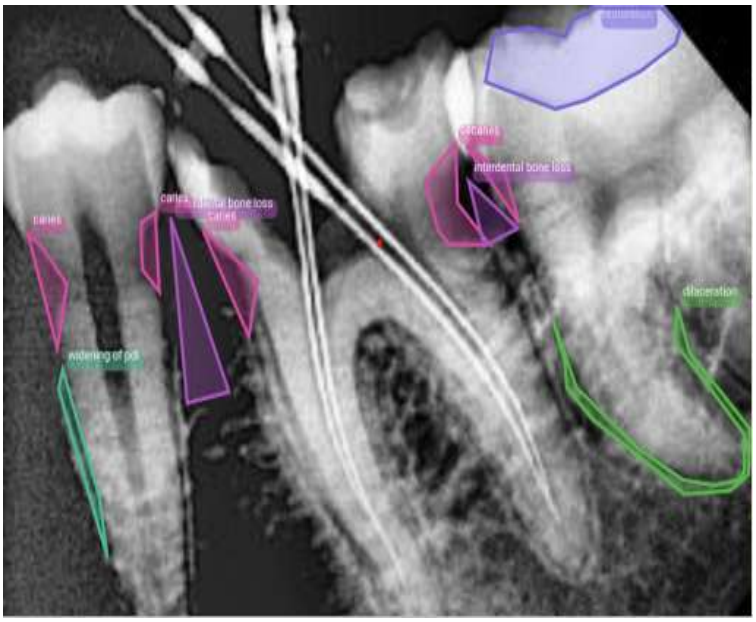

Fig 18: RVG interpreted by using AI showing caries, restoration, interdental bone loss, widened PDL space

CBCT Sialography

CBCT helps improve visualization of the ductal system of salivary glands. Water or oil-soluble contrast media is injected intra-ductally and then CBCT imaging to view the ductal and glandular structures. It can reveal salivary stones, ductal atresia, stenosis, and the normal ductal as well as glandular anatomy. Also, it is superior to

conventional sialography in providing 3-dimensional analysis of salivary gland structures as well as nearby anatomical structures.[18]

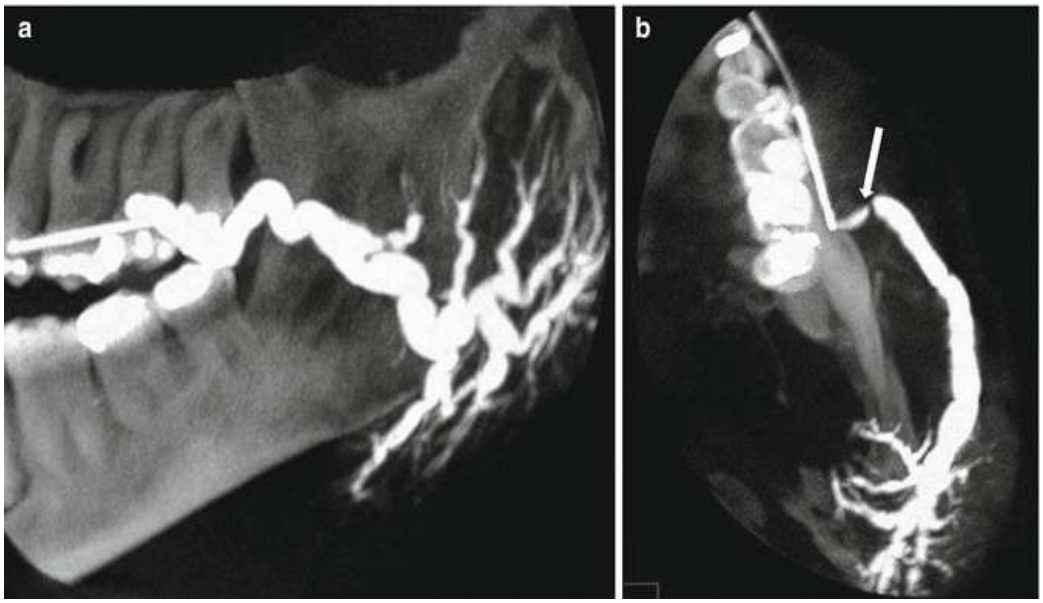

Fig 19: CBCT Sialography of submandibular gland showing normal ductal architecture

3-D Reconstruction

Forensic facial reconstruction is the process of recreating the face of an individual from their skeletal remains using CBCT and anthropometric measurements. Combination Manchester Method or British Method is most commonly used. It is a ray of hope in forensic dentistry where a deceased individual can be identified. [19]

Fig 20: Adding soft tissue mass and to CBCT scans for 3-D facial reconstruction.

3-D Printing

Data obtained by CBCT is processed and uploaded to CAD/CAM system. Using a stereolithography printer or ultraviolet printer, light-sensitive polymers can be used to fabricate models in complex anatomy in a short time. Also, guiding splints and mouth guards can be fabricated with more accuracy affirming the anatomical structures. **3D printing is already shaking out age-old notions of what can and can't be made by digitizing the manufacturing process.**

Fig 21:- CAD-CAM miling for 3-D printing of dental prostheses and other appliances.

Conclusion:-

There is nothing impossible with the current technology and the approach towards diagnosis and treatment plan we are having, but newer methods are like the silver lining of the cloud with better scope, easing our work and saving on time. Most importantly, the non-invasive nature of revolutionary ideas has made them a suitable approach that is not only convenient and handy but also more specific and sensitive.

Technology is a useful servant, but a dangerous master; Using the technological advances to the best of knowledge as an aide with the clinical expertise and experience of a clinician makes the recipe for accurate diagnosis. Technology alone is not sufficient; it needs to be maneuvered to suit individual requirements so that the diagnostic process is simplified and standardized.

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