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Review Article

Recent Diagnostic Aids in Orthodontics: A Literature Review

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ABSTRACT:
The field of orthodontics has witnessed significant advancements in diagnostic aids, enhancing the accuracy of diagnosis and treatment planning. This review examines the latest technologies and methodologies that are reshaping orthodontic diagnostics. Key developments include the integration of Cone Beam Computed Tomography (CBCT), which provides detailed 3D images of dental and skeletal structures, allowing for better visualization and analysis of complex cases. Digital intraoral scanners have largely replaced conventional impressions, resulting in more precise and comfortable patient experiences. Furthermore, the application of artificial intelligence in analyzing dental images promises faster and more reliable diagnoses by identifying anomalies and predicting treatment outcomes. Teleorthodontics is emerging as a valuable tool for remote monitoring, facilitating timely adjustments and enhancing patient engagement. Customized treatment planning software is also gaining traction, enabling orthodontists to simulate and visualize potential outcomes tailored to individual patients. This review highlights the importance of these diagnostic aids in improving treatment accuracy, efficiency, and overall patient satisfaction in modern orthodontic practice.

Keywords: Diagnostic Aids, Orthodontic Treatment, Malocclusion

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INTRODUCTION

In recent years, orthodontics has undergone a transformative shift fueled by the advent of advanced diagnostic aids. The complexity of orthodontic conditions necessitates precise and reliable diagnostic tools, which can significantly influence treatment planning and outcomes. Traditional methods, such as manual measurements and 2D radiographs, often fall short in providing comprehensive insights into the dental and skeletal structures of patients. Consequently, there is a growing demand for innovative technologies that enhance diagnostic capabilities.[1]

This review aims to explore the latest diagnostic aids in orthodontics, focusing on their development, application, and impact on clinical practice. Notably, the integration of three-dimensional imaging techniques, such as Cone Beam Computed Tomography (CBCT), has revolutionized diagnostic accuracy by offering detailed images that facilitate evaluation of both hard and soft tissues.[2-3] Moreover, digital intraoral scanners have streamlined the process of obtaining dental impressions, resulting in increased patient comfort and higher precision in model creation. The role of artificial intelligence in orthodontic diagnostics is also gaining prominence, as machine learning algorithms can analyze radiographic images efficiently, assisting practitioners in identifying conditions that may require intervention.[3-6]

Teleorthodontics has emerged as a valuable approach for patient monitoring and engagement, allowing practitioners to remotely assess progress and make necessary adjustments without the need for frequent office visits. Furthermore, advancements in customized treatment planning software enable orthodontists to devise tailored treatment strategies based on accurate simulations of expected outcomes.[4-7]

In conclusion, the continuous evolution of diagnostic aids in orthodontics holds great promise for enhancing clinical practice, improving treatment outcomes, and ultimately elevating patient satisfaction. This review will delve deeper into each of these innovations, discussing their implications for future orthodontic care.[3] The aim of present review article is to review the recent diagnostic aids which help the Orthodontist in treatment planning.

Objective of Diagnostic Aids in Orthodontics: The primary objectives of diagnostic aids in orthodontics are to enhance the accuracy and efficiency of diagnosis, treatment planning, and patient care. These aids aim to provide detailed visualization of dental and skeletal structures, facilitating precise evaluations of orthodontic conditions. Additionally, they seek to improve patient comfort through advanced imaging and modeling techniques, reduce the risk of errors in treatment planning, and streamline workflows. Ultimately, the goal is to empower orthodontists with the tools necessary to deliver personalized treatment strategies that achieve optimal clinical outcomes while maximizing patient satisfaction.[2-3]

Recent Diagnostic Aids

Digital Orthodontic Records:

Digital study model: To overcome disadvantages of conventional study models, digital models came into existence. Although the cost of digital models is more, but the advantage of negligible storage space and storage cost makes it a better alternative to plaster or stone models.[4]

Digital photography: In photography, the introduction of digital media has simplified both the acquisition and management of still photographs. Extra-oral and intraoral photographs that can also be instantly transferred into the patient's record and viewed on a patient-visible display.[5]

Digital radiography: Using an electronic sensor and imaging system, the radiographs are taken instantaneously on a computer system. Digital radiography requires less x-radiation than conventional radiography. Reduces errors and saves time when compared to conventional radiography.[6]

Cone Beam Computed Tomography: Craniofacial CBCT was created to address some of the drawbacks of traditional CT scanning technology. The object to be examined is captured by a two-dimensional retractor during a craniofacial CBCT scan. Comparatively to a conventional CT device, where numerous slices are stacked to generate a whole image, this straightforward distinction enables a single rotation of the radiation source to capture an entire region of interest. Comparing the cone beam to typical fan-shaped CT machines, the cone beam also generates a more focused beam and significantly less scatter radiation.[7,8]

Clinical Applications in Orthodontics With CBCT:[9-11]

1. Orthodontists have many images that are not possible with conventional radiographic measures.
2. Impacted teeth and oral abnormalities
3. Airway analysis
4. Assessment of alveolar bone height and volume
5. TMJ morphology
6. Lateral and frontal Cephalogram views
7. Skeletal views
8. Facial analysis
9. 3D review of dentition

Advantages[10-12]

1. Increased accuracy of image geometry
2. Eliminates magnification, overlapping and distortion of structures.
3. Assesses image from three planes.
4. To evaluate the areas of clinical interest with localized and specific transversal cuts
5. Easy identification of landmarks and higher precision of superimposed images
6. Fine adjustment of the head position is not required

Disadvantages[10]

1. Amount of radiation is the biggest controversy
2. Due to poor contrast resolution, differentiation of various soft tissues becomes difficult.

Tuned aperture computed tomography: A revolutionary technology for acquiring three-dimensional radiography data was reported by RL Webber. Also called transmission radiography. A number of x-ray projections are made using a reference point to create TACT pictures. They aid in the visualisation of the mouth cavity's hard tissues. A TACT slice can be created from any number of x-ray projections. A reference point created by the fiducial item that is placed above the detection plane should be present in each projection. One x-ray source may be utilised to produce TACT slices, and it may be moved through various points in space to produce various x-ray projections. The identification of periodontal, periapical, and caries disorders is not greatly aided by these pictures.[7]

Digital Cephalometry: The lateral cephalogram can reveal a patient's dental, skeletal, and soft tissue morphology as well as the connections between these parts. Cephalometry is a crucial tool for understanding the morphology and growth of the craniofacial complex, spotting anomalies, foreseeing future connections, and organising orthodontic therapy.[11] The paradigm shift is occurring in orthodontics from the widely accepted film based to digital cephalometry. Rudolph et al. compared the reliability of digital and conventional cephalometric radiographs in terms of landmark identification error.

They concluded similar reproducibility and precision in landmark identification using both direct digital and conventional lateral cephalometric head films.[12]

Digigraph: This technology aids in the measurement of linear distances. They contribute to reducing radiation exposure from patient diagnostics using lateral cephalometric tracings. After the plaster cast is digitized, the mesiodistal breadth of teeth is measured. Digital handpieces were used to collect mesiodistal measurements. The process is as follows: while pressing the handpiece's button, place the tip of the handpiece on the selected landmark for the scan to be performed.[13]

Micro computed tomography (Micro CT): Gary Yip, Paul Schneider, and Eugene W. Roberts reported about the usefulness of micro computed tomography in orthodontic diagnosis. It evolved as a successor to routine histological sectioning and bone assessment using micro radiographic techniques. Micro CT is a new dental technology to detect subtle changes in bony structures in relation orthodontic implants, dentofacial orthopaedics and normal orthodontics. They help to assess the modelling and remodelling of bone in mineralized tissues. This imaging technology is a major breakthrough in dental imaging as it helps to evaluate the supporting bone around dental implants.[14]

Multi detector CT: This is a type of diagnostic computed tomography imaging. The detector elements are arranged in a two-dimensional array. As a result, it aids in the acquisition of several thin slices and speeds up CT imaging. Multiplanar reformation of three-dimensional images and panorama reconstruction are made possible by special algorithms. Aids in the thorough evaluation of pathologic deformities. Its acquisition time is significantly shorter, which lessens the motion artefacts brought on by patient movement. greater soft tissue resolution and less noise and scatter radiation than CBCT. The axial, coronal, sagittal, and oblique or curved picture planes can all be used to create images.[15,16]

Ultrasonography: Sounds are perceived as such by the eardrum due to pressure changes in the surrounding air. These changes happen between 1500 and 20,000 cycles per second (hertz, Hz). The frequency of ultrasound is more than 20 kHz. It is possible to distinguish it from other mechanical waveforms because its vibratory frequency is higher than human hearing range. Diagnostic ultrasonography, a clinical application of ultrasound imaging and analysis, uses a vibratory frequency of 1–20 MHz.Ultrasound is a great alternative because it is a non-invasive, efficient, and affordable diagnostic technique. Ultrasonography has been utilised in a number of investigations to get a static image of the oral cavity, such as the study of tongue morphology and the identification of sialolithiasis, cysts, and malignancies.[17]

3D ultrasound imaging is a new technique that produces more detailed photographs of the fetus's face than earlier 2D imaging methods have managed to achieve. These benefits include being able to adjust planar views without worrying about fetal movement, determining the precise placement of planar pictures with respect to the surface facial image, and giving non-trained observers simple access to realistic 3D visuals. When it comes to diagnosing cleft lip and palate, 3D imaging has substantially greater sensitivity than 2D imaging.[18,19]

Magnetic Resonance Imaging (MRI): The use of repetitive maxillofacial imaging to monitor the progress of orthodontic treatment is essential to effectively treat orthodontic patients. Three dimensional imaging is rapidly replacing traditional radiographic methods. This new technology is particularly helpful with orthodontic concerns such as root length, bone structure, and root angulation. In contrast to CBCT imaging, MRI uses nonionizing electromagnetic radiation. MRI allows for repetitive 3-D imaging of dental structures in any age group without worrying about potential harmful radiation exposure.[20]

Advantages to MRI[21,22]

1. Ability to image the TMJ and disk
2. Display of soft and hard tissues
3. Safe to use for patients, who are allergic to the contrast agent
4. All images can be obtained without repositioning of the patient
5. The ability to see inflammatory processes

Disadvantages to MRI[21,22]

1. Cost of equipment and cost to patients.
2. Accessibility and availability in medical and dental centers.
3. Increased possibility of motion artifact due to the length of time to obtain an image. Hard tissues not recorded as well
4. Discomfort of claustrophobic patients being confined to a small space

DICOM: DICOM (Digital Imaging and Communication in Medicine) is the standard within Medicine for the transmission of radiologic images and other medical information between computers and various devices that acquire images and also between various equipment and software systems that are produced by different manufacturers [5]. A DICOM image file contains the x-ray image or series of images (for example a multiple slice CBCT imaging study) and other patient related information that is selected from a ‘library’ of standardized terms (e.g. patient name, identification number, and acquisition modality to name a few) that can be pre-selected. The DICOM library is extensive and continually updated to reflect changing identification standards. A DICOM compliant image file can be thought of as similar to the 'layered' file that is created in the Adobe Photoshop software or a JPEG with the information embedded in the data 'set' or metafile.Because of DICOM, picture archiving and transmission technologies have grown in popularity. Its primary purpose is to help in the diagnosis and planning of treatment and to provide a 3D record of the original malocclusion, at any stages of correction, and the final treatment outcome.[24-27]

CONCLUSION

The integration of recent diagnostic aids in orthodontics has significantly enhanced the precision and effectiveness of treatment strategies. Notably, three-dimensional imaging technologies, such as Cone Beam Computed Tomography, provide orthodontists with superior visualization of anatomical structures, allowing for more accurate assessments and tailored treatment plans that lead to better patient outcomes. Additionally, the shift from traditional impressions to digital intraoral scanners has improved patient comfort and increased the accuracy of model creation, minimizing errors associated with conventional methods and enabling quicker turnaround times for aligner and appliance fabrication. Furthermore, the utilization of artificial intelligence in image analysis presents a revolutionary approach to diagnostics, efficiently identifying anomalies in radiographs and scans, which enhances decision-making and empowers orthodontists to make informed treatment choices with greater confidence. Together, these advancements underscore a transformative era in orthodontics, focused on improving clinical results and patient experiences.

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